TGD AND
QUANTUM BIOLOGY: PART I

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0.1 PREFACE

Brief summary of TGD

Towards the end of the year 2023 I became convinced that it would be appropriate to prepare collections about books related to TGD and its applications. The finiteness of human lifetime was my first motivation. My second motivation was the deep conviction that TGD will mean a revolution of the scientific world view and I must do my best to make it easier.

The first collection would relate to the TGD proper and its applications to physics. Second collection would relate to TGD inspired theory of consciousness and the third collection to TGD based quantum biology. The books in these collections would focus on much more precise topics than the earlier books and would be shorter. This would make it much easier for the reader to understand what TGD is, when the time is finally mature for the TGD to be taken seriously. This particular book belongs to a collection of books about TGD proper.

The basic ideas of TGD

TGD can be regarded as a unified theory of fundamental interactions but is not the kind of unified theory as so called GUTs constructed by graduate students in the seventies and eighties using detailed recipes for how to reduce everything to group theory. Nowadays this activity has been completely computerized and it probably takes only a few hours to print out the predictions of this kind of unified theory as an article in the desired format. TGD is something different and I am not ashamed to confess that I have devoted the last 45 years of my life to this enterprise and am still unable to write The Rules.

If I remember correctly, I got the basic idea of Topological Geometrodynamics (TGD) during autumn 1977, perhaps it was October. What I realized was that the representability of physical space-times as 4-dimensional surfaces of some higher-dimensional space-time obtained by replacing the points of Minkowski space with some very small compact internal space could resolve the conceptual difficulties of general relativity related to the definition of the notion of energy. This belief was too optimistic and only with the advent of what I call zero energy ontology the understanding of the notion of Poincare invariance has become satisfactory. This required also the understanding of the relationship to General Relativity.

It soon became clear that the approach leads to a generalization of the notion of space-time with particles being represented by space-time surfaces with finite size so that TGD could be also seen as a generalization of the string model. Much later it became clear that this generalization is consistent with conformal invariance only if space-time is 4-dimensional and the Minkowski space factor of the embedding space is 4-dimensional. During last year it became clear that 4-D Minkowski space and 4-D complex projective space CP_2 are completely unique in the sense that they allow twistor space with Kähler structure.

It took some time to discover that also the geometrization of also gauge interactions and elementary particle quantum numbers could be possible in this framework: it took two years to find the unique internal space (CP_2) providing this geometrization involving also the realization that family replication phenomenon for fermions has a natural topological explanation in TGD framework and that the symmetries of the standard model symmetries are much more profound than pragmatic TOE builders have believed them to be. If TGD is correct, the mainstream particle physics chose the wrong track leading to the recent deep crisis when people decided that quarks and leptons belong to the same multiplet of the gauge group implying instability of the proton.

Instead of trying to describe in detail the path, which led to TGD as it is now with all its side tracks, it is better to summarize the recent view which of course need not be final.

TGD can be said to be a fusion of special and general relativities. The Relativity Principle (Poincare Invariance) of Special Relativity is combined with the General Coordinate Invariance and Equivalence Principle of General Relativity. TGD involves 3 views of physics: physics geometry, physics as number theory and physics as topological physics in some sense.

Physics as geometry

"Geometro-" in TGD refers to the idea about the geometrization of physics. The geometrization program of Einstein is extended to gauge fields allowing realization in terms of the geometry of surfaces so that Einsteinian space-time as abstract Riemann geometry is replaced with sub-manifold geometry. The basic motivation is the loss of classical conservation laws in General Relativity Theory (GRT)(see **Fig. 12**). Also the interpretation as a generalization of string models by replacing string with 3-D surface is natural.

- Standard model symmetries uniquely fix the choice of 8-D space in which space-time surfaces live to $H = M^4 \times CP_2$ [L135]. Also the notion of twistor is geometrized in terms of surface geometry and the existence of twistor lift fixes the choice of H completely so that TGD is unique [L52, L73](see **Fig. 13**). The geometrization applies even to the quantum theory itself and the space of space-time surfaces - "world of classical worlds" (WCW) - becomes the basic object endowed with Kähler geometry (see **Fig. 14**). The mere mathematical existence of WCW geometry requires that it has maximal isometries, which together twistor lift and number theoretic vision fixes it uniquely [L136].

- General Coordinate Invariance (GCI) for space-time surfaces has dramatic implications. A given 3-surface fixes the space-time surface almost completely as analog of Bohr orbit (preferred extremal). This implies holography and leads to zero energy ontology (ZEO) in which quantum states are superpositions of space-time surfaces [K126, L92].

- From the beginning it was clear that the theory predicts the presence of long ranged classical electro-weak and color gauge fields and that these fields necessarily accompany classical electromagnetic fields in all scales. It took about 26 years to gain the maturity to admit the obvious: these fields are classical correlates for long range color and weak interactions assignable to the phases of ordinary matter predicted by the number theoretic vision and behaving like dark matter but identifiable as matter explaining the missing baryon problem whereas the galactic dark matter would correspond to the dark energy assignable monopole flux tubes as deformations of cosmic strings. The only possible conclusion is that TGD physics is a fractal consisting of an entire hierarchy of fractal copies of standard model physics. Also the understanding of electro-weak massivation and screening of weak charges has been a long standing problem and p-adic physics solved this problem in terms of p-adic thermodynamics [K33, K64] [L125].

- One of the most recent discoveries of classical TGD is exact general solution of the field equations. Holography can be realized as a generalized holomorphy realized in terms of what I call Hamilton-Jacobi structure [L131]. Space-time surfaces correspond to holomorphic imbeddings of the space-time surface to H with a generalized complex structure defined by the vanishing of 2 analytic functions of 4 generalized complex coordinates of H. These surfaces are automatically minimal surfaces. This is true for any geneneral coordinate invariant action constructed in terms of the induced geometric structures so that the dynamics is universal. Different actions differ only in the sense that singularities at which the minimal surface property fails depend on the action. This affects the scattering amplitudes, which can be constructed in terms of the data related to the singularities [L141].

- Generalized conformal symmetries define an extension of conformal symmetries and one can assign to them Noether charges. Besides this the so called super-symplectic symmetries associated with $\delta M_+^4 \times CP_2$ define isometries of the "world of classical worlds" (WCW), which by holography is essentially the space of Bohr orbits of 3-surfaces as particles so that quantum TGD is expected to reduce to a generalization of wave mechanics.

Physics as number theory

During these years TGD led to a rather profound generalization of the space-time concept. Quite general properties of the theory led to the notion of many-sheeted space-time with sheets representing physical subsystems of various sizes. At the beginning of 90s I became dimly aware of the

importance of p-adic number fields and soon ended up with the idea that p-adic thermodynamics for a conformally invariant system allows to understand elementary particle massivation with amazingly few input assumptions. The attempts to understand p-adicity from basic principles led gradually to the vision about physics as a generalized number theory as an approach complementary to the physics as an infinite-dimensional spinor geometry of WCW approach. One of its elements was a generalization of the number concept obtained by fusing real numbers and various p-adic numbers along common rationals. The number theoretical trinity involves besides p-adic number fields also quaternions and octonions and the notion of infinite prime.

Adelic physics [L50, L51] fusing real and various p-adic physics is part of the number theoretic vision, which provides a kind of dual description for the description based on space-time geometry and the geometry of "world of classical words". Adelic physics predicts two fractal length scale hierarchies: p-adic length scale hierarchy and the hierarchy of dark length scales labelled by $h_{eff} = nh_0$, where n is the dimension of extension of rational. The interpretation of the latter hierarchy is as phases of ordinary matter behaving like dark matter. Quantum coherence is possible in arbitarily long scales. These two hierarchies are closely related. p-Adic primes correspond to ramified primes for a polynomial, whose roots define the extension of rationals: for a given extension this polynomial is not unique.

$M^8 - H$ duality

The concrete realization of the number theoretic vision is based on $M^8 - H$ duality (see **Fig. 15**). What the precise form is this duality is, has been far from clear but the recent form is the simplest one and corresponds to the original view [L138]. M^8 corresponds to octonions O but with the number theoretic metric defined by $Re(o^2)$ rather than the standard norm and giving Minkowskian signature.

The physics in M^8 can be said to be algebraic whereas in H field equations are partial differential equations. The dark matter hierarchy corresponds to a hierarchy of algebraic extensions of rationals inducing that for adeles and has interpretation as an evolutionary hierarchy (see **Fig. 16**). p-Adic physics is an essential part of number theoretic vision and the space-time surfaces are such that at least their M^8 counterparts exists also in p-adic sense. This requires that the analytic function defining the space-time surfaces are polynomials with rational coefficients.

$M^8 - H$ duality relates two complementary visions about physics (see **Fig. 17**), and can be seen as a generalization of the momentum-position duality of wave mechanics, which fails to generalize to quantum field theories (QFTs). $M^8 - H$ duality applies to particles which are 3-surfaces instead of point-like particles.

p-Adic physics

The idea about p-adic physics as physics of cognition and intentionality emerged also rather naturally and implies perhaps the most dramatic generalization of the space-time concept in which most points of p-adic space-time sheets are infinite in real sense and the projection to the real imbedding space consists of discrete set of points. One of the most fascinating outcomes was the observation that the entropy based on p-adic norm can be negative. This observation led to the vision that life can be regarded as something in the intersection of real and p-adic worlds. Negentropic entanglement has interpretation as a correlate for various positively colored aspects of conscious experience and means also the possibility of strongly correlated states stable under state function reduction and different from the conventional bound states and perhaps playing key role in the energy metabolism of living matter.

If one requires consistency of Negentropy Mazimization Principle with standard measurement theory, negentropic entanglement defined in terms of number theoretic negentropy is necessarily associated with a density matrix proportional to unit matrix and is maximal and is characterized by the dimension n of the unit matrix. Negentropy is positive and maximal for a p-adic unique prime dividing n.

Hierarchy of Planck constants labelling phases ordinary matter dark matter behaving like dark matter

One of the latest threads in the evolution of ideas is not more than nine years old. Learning about the paper of Laurent Nottale about the possibility to identify planetary orbits as Bohr orbits with a gigantic value of gravitational Planck constant made once again possible to see the obvious. Dynamical quantized Planck constant is strongly suggested by quantum classical correspondence and the fact that space-time sheets identifiable as quantum coherence regions can have arbitrarily large sizes. Second motivation for the hierarchy of Planck constants comes from bio-electromagnetism suggesting that in living systems Planck constant could have large values making macroscopic quantum coherence possible. The interpretation of dark matter as a hierarchy of phases of ordinary matter characterized by the value of Planck constant is very natural.

During summer 2010 several new insights about the mathematical structure and interpretation of TGD emerged. One of these insights was the realization that the postulated hierarchy of Planck constants might follow from the basic structure of quantum TGD. The point is that due to the extreme non-linearity of the classical action principle the correspondence between canonical momentum densities and time derivatives of the imbedding space coordinates is one-to-many and the natural description of the situation is in terms of local singular covering spaces of the imbedding space. One could speak about effective value of Planck constant $h_{eff} = n \times h$ coming as a multiple of minimal value of Planck constant. Quite recently it became clear that the non-determinism of Kähler action is indeed the fundamental justification for the hierarchy: the integer n can be also interpreted as the integer characterizing the dimension of unit matrix characterizing negentropic entanglement made possible by the many-sheeted character of the space-time surface.

Due to conformal invariance acting as gauge symmetry the n degenerate space-time sheets must be replaced with conformal equivalence classes of space-time sheets and conformal transformations correspond to quantum critical deformations leaving the ends of space-time surfaces invariant. Conformal invariance would be broken: only the sub-algebra for which conformal weights are divisible by n act as gauge symmetries. Thus deep connections between conformal invariance related to quantum criticality, hierarchy of Planck constants, negentropic entanglement, effective p-adic topology, and non-determinism of Kähler action perhaps reflecting p-adic non-determinism emerges.

The implications of the hierarchy of Planck constants are extremely far reaching so that the significance of the reduction of this hierarchy to the basic mathematical structure distinguishing between TGD and competing theories cannot be under-estimated.

TGD as an analog of topological QFT

Consider next the attribute "Topological". In condensed matter physical topological physics has become a standard topic. Typically one has fields having values in compact spaces, which are topologically non-trivial. In the TGD framework space-time topology itself is non-trivial as also the topology of $H = M^4 \times CP_2$. Since induced metric is involved with TGD, it is too much to say that TGD is topological QFT but one can for instance say, that space-time surfaces as preferred extremals define representatives for 4-D homological equivalence classes.

The space-time as 4-surface $X^4 \subset H$ has a non-trivial topology in all scales and this together with the notion of many-sheeted space-time brings in something completely new. Topologically trivial Einsteinian space-time emerges only at the QFT limit in which all information about topology is lost (see **Fig. 18**).

Any GCI action satisfying holography=holomorphy principle has the same universal basic extremals: CP_2 type extremals serving basic building bricks of elementary particles, cosmic strings and their thickenings to flux tubes defining a fractal hierarchy of structure extending from CP_2 scale to cosmic scales, and massless extremals (MEs) define space-time correletes for massless particles. World as a set or particles is replaced with a network having particles as nodes and flux tubes as bonds between them serving as correlates of quantum entanglement.

"Topological" could refer also to p-adic number fields obeying p-adic local topology differing radically from the real topology (see **Fig. 19**).

Zero energy ontology

TGD inspired theory of consciousness entered the scheme after 1995 as I started to write a book about consciousness. Gradually it became difficult to say where physics ends and consciousness theory begins since consciousness theory could be seen as a generalization of quantum measurement theory by identifying quantum jump as a moment of consciousness and by replacing the observer with the notion of self identified as a system which is conscious as long as it can avoid entanglement with environment. The somewhat cryptic statement "Everything is conscious and consciousness can be only lost" summarizes the basic philosophy neatly.

General coordinate invariance leads to the identification of space-time surfaces are analogous to Bohr orbits inside causal diamond (CD). CD obtained as intersection of future and past directed light-cones (with CP_2 factor included). By the already described hologamphy, 3-dimensional data replaces the boundary conditions at single 3-surface involving also normal derivatives with conditions involving no derivates.

In zero energy ontology (ZEO), the superpositions of space-time surfaces inside causal diamond (CD) having their ends at the opposite light-like boundaries of CD, define quantum states. CDs form a scale hierarchy (see **Fig. 20** and **Fig. 21**). Quantum states are modes of WCW spinor fields, essentially wave functions in the space WCW consisting of Bohr orbit-like 4-surfaces.

Quantum jumps occur between these and the basic problem of standard quantum measurement theory disappears. Ordinary state function reductions (SFRs) correspond to "big" SFRs (BSFRs) in which the arrow of time changes (see **Fig. 22**). This has profound thermodynamic implications and the question about the scale in which the transition from classical to quantum takes place becomes obsolete. BSFRs can occur in all scales but from the point of view of an observer with an opposite arrow of time they look like smooth time evolutions.

In "small" SFRs (SSFRs) as counterparts of "weak measurements" the arrow of time does not change and the passive boundary of CD and states at it remain unchanged (Zeno effect).

Equivalence Principle in TGD framework

There have been also longstanding problems related to the relationship between inertial mass and gravitational mass, whose identification has been far from obvious.

- Gravitational energy is well-defined in cosmological models but is not conserved. Hence the conservation of the inertial energy does not seem to be consistent with the Equivalence Principle. In this framework the quantum numbers are assigned with zero energy states located at the boundaries of CDs defined as intersections of future and past directed light-cones. The notion of energy-momentum becomes length scale dependent since one has a scale hierarchy for causal diamonds. This allows to understand the non-conservation of energy as apparent.

  Equivalence Principle in the form expressed by Einstein's equations follows from Poincare invariance once it is realized that GRT space-time is obtained from the many-sheeted space-time of TGD by lumping together the space-time sheets to a regionof Minkowski space and endowing it with an effective metric given as a sum of Minkowski metric and deviations of the metrices of space-time sheets from Minkowski metric. Similar description relates classical gauge potentials identified as components of induced spinor connection to Yang-Mills gauge potentials in GRT space-time. Various topological inhomogenities below resolution scale identified as particles are described using energy momentum tensor and gauge currents.

  At quantum level, the Equivalence Principle has a surprisingly strong content. In linear Minkowski coordinates, space-time projection of the M^4 spinor connection representing gravitational gauge potentials the coupling to induced spinor fields vanishes. Also the modified Dirac action for the solutions of the modified Dirac equation seems to vanish identically and in TGD perturbative approach separating interaction terms is not possible.

  The modified Dirac equation however fails at the singularities of the minimal surface representing space-time surface and Dirac action reduces to an integral over singularities for the trace of the second fundamental form slashed between the induced spinor field and its conjugate. Also the M^4 part of the trace is non-vanishing and gives rise to the gravitational coupling. The trace gives both standard model vertices and graviton emission vertices. One

could say that at the quantum level gravitational and gauge interactions are eliminated everywhere except at the singularities identifiable as defects of the ordinary smooth structure. The exotic smooth structures [L120], possible only in dimension 4, are ordinary smooth structures apart from these defects serving as vertex representing a creation of a fermion-antifermion pair in the induced gauge potentials. The vertex is universal and essentially the trace of the second fundamental form as an analog of the Higgs field and the gravitational constant is proportional to the square of CP_2 radius.

- There is a delicate difference between inertial and gravitational masses. One can assume that the modes of the imbedding space spinor fields are solutions of massles Dirac equation in either $M^4 \times CP_2$ and therefore eigenstates of inertial momentum or in $CD = cd \times CP_2$: in this case they are only mass eigenstates. The mass spectra are identical for these options. Inertial momenta correspond naturally to the Poincare charges in the space of CDs. For the CD option the spinor modes correspond to mass squared eigenstates for which the mode for H^3 with a given value of light-proper time is a unitary irreducible $SO(1,3)$ representation rather than a representation of translation group. These two eigenmode basis correspond to gravitational basis for spinor modes.

Quantum TGD as a generalization of Einstein's geometrization program

I started the serious attempts to construct quantum TGD after my thesis around 1982. The original optimistic hope was that path integral formalism or canonical quantization might be enough to construct the quantum theory but it turned that this approach fails due to the extreme non-linearity of the theory.

It took some years to discover that the only working approach is based on the generalization of Einstein's program. Quantum physics involves the geometrization of the infinite-dimensional "world of classical worlds" (WCW) identified as the space of 3-dimensional surfaces. Later 3-surfaces where replaced with 4-surfaces satifying holography and therefore as analogs of Bohr orbits.

- If one assumes Bohr orbitology, then strong correlations between the 3-surfaces at the ends of CD follow and mean holography. It is natural to identify the quantum states of the Universe (and sub-Univeverses) as modes of a formally classical spinor field in WCW. WCW gamma matrices are expressible in terms of oscillator operators of free second quantized spinor fields of H. The induced spinor fields identified projections of H spinor fields to the space-time surfaces satisfy modified Dirac equation for the modified Dirac equation. Only quantum jump remains the genuinely quantal aspect of quantum physics.

- Quantum TGD can be seen as a theory for free spinor fields in WCW having maximal isometries and the generalization of the Super Virasoro conditions gives rise to the analog massless Dirac equation at the level of WCW.

The world of classical worlds and its symmetries

The notion of "World of Classical Worlds" (WCW) emerged around 1985 but found its basic form around 1990. Holography forced by the realization of General Coordinate Invariance forced/allowed to give up the attempts to make sense of the path integral.

A more concrete way to express this view is that WCW does not consist of 3-surfaces as particle-like entities but almost deterministic Bohr orbits assignable to them as preferred extremals of Kähler action so that quantum TGD becomes wave mechanics in WCW combined with Bohr orbitology. This view has profound implications, which can be formulated in terms of zero energy ontology (ZEO), solving among other things the basic paradox of quantum measurement theory. ZEO forms also the backbone of TGD inspired theory of consciousness and quantum biology.

WCW geometry exists only if it has maximal isometries: this statement is a generalization of the discovery of Freed for loop space geometries [A12]. I have proposed [K55, K35, K123, K99, L136] that WCW could be regarded as a union of generalized symmetric spaces labelled by zero modes which do not contribute to the metric. The induced Kähler field is invariant under symplectic transformations of CP_2 and would therefore define zero mode degrees of freedom if one assumes

that WCW metric has symplectic transformations as isometries. In particular, Kähler magnetic fluxes would define zero modes and are quantized closed 2-surfaces. The induced metric appearing in Kähler action is however not zero mode degree of freedom. If the action contains volume term, the assumption about union of symmetric spaces is not well-motivated.

Symplectic transformations are not the only candidates for the isometries of WCW. The basic picture about what these maximal isometries could be, is partially inspired by string models.

- A weaker proposal is that the symplectomorphisms of H define only symplectomorphisms of WCW. Extended conformal symmetries define also a candidate for isometry group. Remarkably, light-like boundary has an infinite-dimensional group of isometries which are in 1-1 correspondence with conformal symmetries of $S^2 \subset S^2 \times R_+ = \delta M_+^4$.

- Extended Kac Moody symmetries induced by isometries of δM_+^4 are also natural candidates for isometries. The motivation for the proposal comes from physical intuition deriving from string models. Note they do not include Poincare symmetries, which act naturally as isometries in the moduli space of causal diamonds (CDs) forming the "spine" of WCW.

- The light-like orbits of partonic 2-surfaces might allow separate symmetry algebras. One must however notice that there is exchange of charges between interior degrees of freedom and partonic 2-surfaces. The essential point is that one can assign to these surface conserved charges when the dual light-like coordinate defines time coordinate. This picture also assumes a slicing of space-time surface by by the partonic orbits for which partonic orbits associated with wormrhole throats and boundaries of the space-time surface would be special. This slicing would correspond to Hamilton-Jacobi structure.

- Fractal hierarchy of symmetry algebras with conformal weights, which are non-negative integer multiples of fundamental conformal weights, is essential and distinguishes TGD from string models. Gauge conditions are true only the isomorphic subalgebra and its commutator with the entire algebra and the maximal gauge symmetry to a dynamical symmetry with generators having conformal weights below maximal value. This view also conforms with p-adic mass calculations.

- The realization of the symmetries for 3-surfaces at the boundaries of CD and for light-like orbits of partonic 2-surfaces is known. The problem is how to extend the symmetries to the interior of the space-time surface. It is natural to expect that the symmetries at partonic orbits and light-cone boundary extend to the same symmetries.

After the developments towards the end of 2023, it seems that the extension of conformal and Kac-Moody symmetries of string models to the TGD framework is understood. What about symplectic symmetries, which were originally proposed as isometries of WCW? In this article this question is discussed in detail and it will be found that these symmetries act naturally on 3-D holographic data and one can identify conserved charges. By holography this is in principle enough and might imply that the actions of holomorphic and symplectic symmetry algebras are dual. Holography=holomorphy hypothesis is discussed also in the case of the modified Dirac equation.

About the construction of scattering amplitudes

From the point of view of particle physics the ultimate goal is of course a practical construction recipe for the S-matrix of the theory. I have myself regarded this dream as quite too ambitious taking into account how far-reaching re-structuring and generalization of the basic mathematical structure of quantum physics is required. After having made several guesses for what the counterpart of S-matrix could be, it became clear that the dream about explicit formulas is unrealistic before one has understood what happens in quantum jump.

- In ZEO [K126, L92] one must distinguish between "small" state function reductions (SSFRs) and "big" SFRs (BSFRs). BSFR is the TGD counterpart of the ordinary SFRs and the arrow of the geometric time changes in it. SSFR follows the counterpart of a unitary time evolution and the arrow of the geometric time is preserved in SSFR. The sequence of SSFRs

is the TGD counterpart for the sequence of repeated quantum measurements of the same observables in which nothing happens to the state. In TGD something happens in SSFRs and this gives rise to the flow of consciousness. When the set of the observables measured in SSFR does not commute with the previous set of measured observables, BSFR occurs.

The evolution by SSFRs means that also the causal diamond changes. At quantum level one has a wave function in the finite-dimensional moduli space of CDs which can be said to form a spine of WCW [L133]. CDs form a scale hierarchy. SSFRs are preceded by a dispersion in the moduli space of CDs and SSFR means localization in this space.

- There are several S-matrix like entities. One can assign an analog of the S-matrix to each analog of unitary time evolution preceding a given SSFR. One can also assign an analog S-matrix between the eigenstate basis of the previous set of observables and the eigenstate basis of new observers: this S-matrix characterizes BSFR. One can also assign to zero energy states an S-matrix like entity between the states assignable to the two boundaries of CD. These S-matrix like objects can be interpreted as a complex square root of the density matrix representable as a diagonal and positive square root of density matrix and unitary S-matrix so that quantum theory in ZEO can be said to define a square root of thermodynamics at least formally.

In standard QFTs Feynman diagrams provide the description of scattering amplitudes. The beauty of Feynman diagrams is that they realize unitarity automatically via the so-called Cutkosky rules. In contrast to Feynman's original beliefs, Feynman diagrams and virtual particles are taken only as a convenient mathematical tool in quantum field theories. The QFT approach is however plagued by UV and IR divergences and one must keep mind open for the possibility that a genuine progress might mean opening of the black box of the virtual particle.

In the TGD framework this generalization of Feynman diagrams indeed emerges unavoidably.

- The counterparts of elementary particles can be identified as closed monopole flux tubes connecting two parallel Minkowskian space-time sheets and have effective ends which are Euclidean wormhole contacts. The 3-D light-like boundaries of wormhole contacts as orbits of partonic 2-surfaces.

The intuitive picture is that the 3-D light-like partonic orbits replace the lines of Feynman diagrams and vertices are replaced by 2-D partonic 2-surfaces. A stronger condition is that fermion number is carried by light-like fermion lines at the partonic orbits, which can be identified as boundaries string world sheets.

- The localization of the nodes of induced spinor fields to 2-D string world sheets (and possibly also to partonic 2-surfaces) implies a stringy formulation of the theory analogous to stringy variant of twistor formalism with string world sheets having interpretation as 2-braids. In the TGD framework, the fermionic variant of twistor Grassmann formalism combined with the number theoretic vision [L114, L115] led to a stringy variant of the twistor diagrammatics.

- Fundamental fermions are off-mass-shell in the sense that their momentum components are real algebraic integers in an extension of rationals associated with the space-time surfaces inside CD with a momentum unit determined by the CD size scale. Galois confinement states that the momentum components are integer valued for the physical states.

- The twistorial approach suggests also the generalization of the Yangian symmetry to infinite-dimensional super-conformal algebras, which would determine the vertices and scattering amplitudes in terms of poly-local symmetries.

The twistorial approach is however extremely abstract and lacks a concrete physical interpretation. The holography=holomorphy vision led to a breakthough in the construction of the scattering amplitudes by solving the problem of identifying interaction vertices [L141].

1. The basic prediction is that space-time surfaces as analogs of Bohr orbits are holomorphic in a generalized sense and are therefore minimal surfaces. The minimal surface property fails at lower-dimensional singularities and the trace of the second fundamental form (SFF) analogous to acceleration associated with the Bohr orbit of the particle as 3-surface has a delta function like singularity but vanishes elsewhere.

2. The minimal surface property expressess masslessness for both fields and particles as 3-surfaces. At singularities masslessness property fails and singularities can be said to serve as sources which also in QFT define scattering amplitudes.

3. The singularities are analogs of poles and cuts for the 4-D generalization of the ordinary holomorphic functions. Also for the ordinary holomorphic functions the Laplace equation as analog massless field equation and expressing analyticity fails. Complex analysis generalizes to dimension 4.

4. The conditions at the singularity give a generalization of Newton's "F=ma"! I ended up where I started more than 50 years ago!

5. In dimension 4, and only there, there is an infinite number of exotic diff structures [**?**], which differ from ordinary ones at singularities of measure zero analogous to defects. These defects correspond naturally to the singularities of minimal surfaces. One can say that for the exotic diff structure there is no singularity.

6. Group theoretically the trace of the SFF can be regarded as a generalization of the Higgs field, which is non-vanishing only at the vertices and this is enough. Singularities take the role of generalized particle vertices and determine the scattering amplitudes. The second fundamental form contracted with the embedding space gamma matrices and slashed between the second quantized induced spinor field and its conjugate gives the universal vertex involving only fermions (bosons are bound states of fermions in TGD). It contains both gauge and gravitational contributions to the scattering amplitudes and there is a complete symmetry between gravitational and gauge interactions. Gravitational couplings come out correctly as the radius squared of CP_2 as also in the classical picture.

7. The study of the modified Dirac equation leads to the conclusion that vertices as singularities and defects contain the standard electroweak gauge contribution coming from the induced spinor connection and a contribution from the M^4 spinor connection. M^4 part of the generalized Higgs can give rise to a graviton as an $L = 1$ rotational state of the flux tube representing the graviton. It is not clear whether M^4 Kähler gauge potential can give rise to a spin 1 particle. The vielbein part of M^4 spinor connection is pure gauge and could give rise to gravitational topological field theory.

Figures

Basic ideas of TGD inspired quantum biology

The following list gives the basic elements of TGD inspired quantum biology.

- Many-sheeted space-time allows the interpretation of the structures of macroscopic world around us in terms of space-time topology. Magnetic/field body acts as intentional agent using biological body as a sensory receptor and motor instrument and controlling biological body and inheriting its hierarchical fractal structure. Fractal hierarchy of EEGs and its variants can be seen as communication and control tools of magnetic body. Also collective levels of consciousness have a natural interpretation in terms of magnetic body. Magnetic body makes also possible entanglement in macroscopic length scales. The braiding of magnetic flux tubes makes possible topological quantum computations and provides a universal mechanism of memory. One can also undersand the real function of various information molecules and corresponding receptors by interpreting the receptors as addresses in quantum computer memory and information molecules as ends of flux tubes which attach to these receptors to form a connection in quantum web.

  Note that also the notion of electric body makes sense [L127]. Quite generally, long range classical gravitational, electric and magnetic fields give rise to very large values of effective Planckl constants. The Nottale's hypothesis of gravitational Planck constant generalizes to electric interactions.
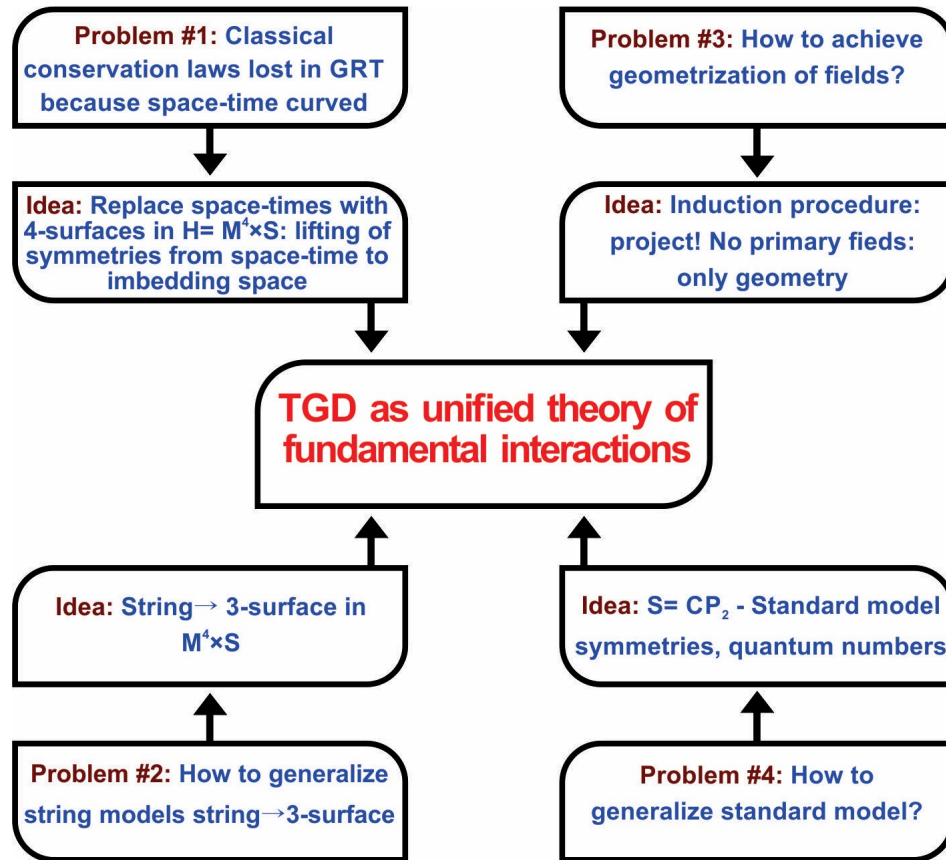
Figure 1: The problems leading to TGD as their solution.

- Magnetic body carrying dark matter and forming an onion-like structure with layers characterized by large values of Planck constant is the key concept of TGD inspired view about Quantum Mind to biology.. Magnetic body is identified as intentional agent using biological body as sensory receptor and motor instrument. EEG and its fractal variants are identified as a communication and control tool of the magnetic body and a fractal hierarchy of analogs of EEG is predicted. Living system is identified as a kind of Indra's net with biomolecules representing the nodes of the net and magnetic flux tubes connections between then.

  The reconnection of magnetic flux tubes and phase transitions changing Planck constant and therefore the lengths of the magnetic flux tubes are identified as basic mechanisms behind DNA replication and analogous processes and also behind the phase transitions associated with the gel phase in cell interior. The braiding of magnetic flux makes possible universal memory representation recording the motions of the basic units connected by flux tubes. Braiding also defines topological quantum computer programs updated continually by the flows of the basic units. The model of DNA as topological quantum computer is discussed as an application. In zero energy ontology the braiding actually generalize to 2-braiding for string world sheets in 4-D space-time and brings in new elements.

- Zero energy ontology (ZEO) makes possible the proposed p-adic description of intentions and cognitions and their transformations to action. Time mirror mechanism based on sending of negative energy signal to geometric past would apply to both long term memory recall, remote metabolism, and realization of intentional acting as an activity beginning in the geometric past in accordance with the findings of Libet. ZEO gives a precise content to the notion of negative energy signal in terms of zero energy state for which the arrow of geometric time is opposite to the standard one.
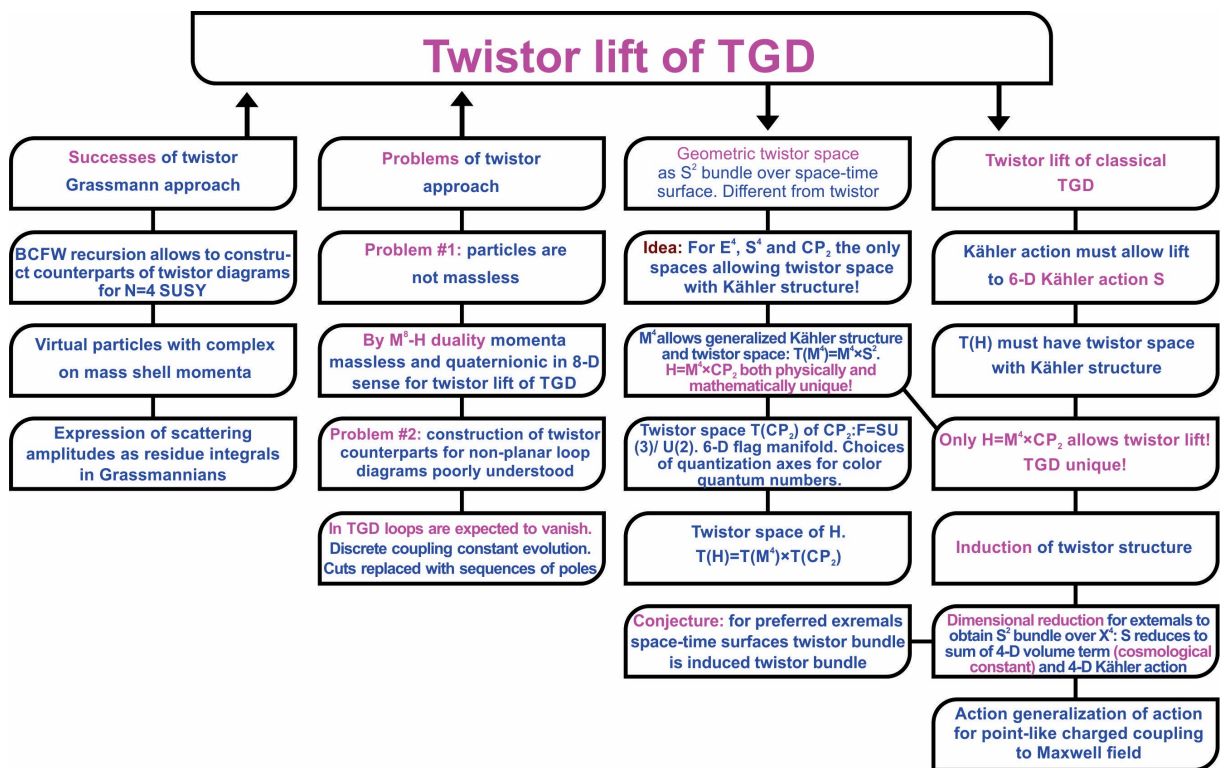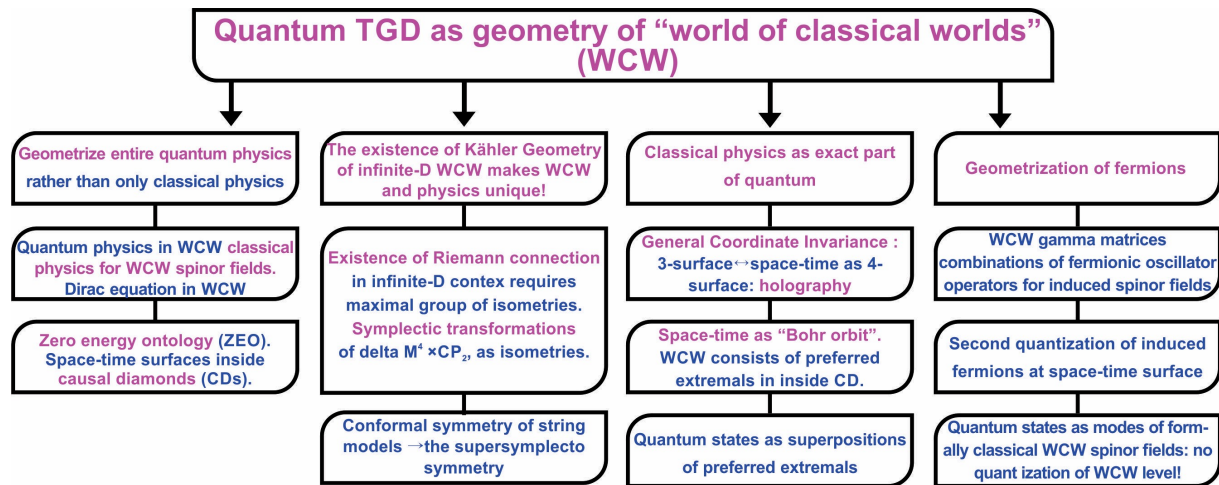
Twistor lift of TGD

Successes of twistor Grassmann approach

BCFW recursion allows to construct counterparts of twistor diagrams for N=4 SUSY

Virtual particles with complex on mass shell momenta

Expression of scattering amplitudes as residue integrals in Grassmannians

Problems of twistor approach

Problem #1: particles are not massless

By M^8-H duality momenta massless and quaternionic in 8-D sense for twistor lift of TGD

Problem #2: construction of twistor counterparts for non-planar loop diagrams poorly understood

In TGD loops are expected to vanish. Discrete coupling constant evolution. Cuts replaced with sequences of poles

Geometric twistor space as S^2 bundle over space-time surface. Different from twistor

Idea: For E^4, S^4 and CP_2 the only spaces allowing twistor space with Kähler structure!

M^4 allows generalized Kähler structure and twistor space: $T(M^4)=M^4 \times S^2$. $H=M^4 \times CP_2$ both physically and mathematically unique!

Twistor space $T(CP_2)$ of CP_2: F=SU(3)/ U(2). 6-D flag manifold. Choices of quantization axes for color quantum numbers.

Twistor space of H. $T(H)=T(M^4) \times T(CP_2)$

Conjecture: for preferred exremals space-time surfaces twistor bundle is induced twistor bundle

Twistor lift of classical TGD

Kähler action must allow lift to 6-D Kähler action S

T(H) must have twistor space with Kähler structure

Only $H=M^4 \times CP_2$ allows twistor lift! TGD unique!

Induction of twistor structure

Dimensional reduction for extremals to obtain S^2 bundle over X^4: S reduces to sum of 4-D volume term (cosmological constant) and 4-D Kähler action

Action generalization of action for point-like charged coupling to Maxwell field

Figure 2: Twistor lift

Quantum TGD as geometry of "world of classical worlds" (WCW)

Geometrize entire quantum physics rather than only classical physics

Quantum physics in WCW classical physics for WCW spinor fields. Dirac equation in WCW

Zero energy ontology (ZEO). Space-time surfaces inside causal diamonds (CDs).

The existence of Kähler Geometry of infinite-D WCW makes WCW and physics unique!

Existence of Riemann connection in infinite-D contex requires maximal group of isometries. Symplectic transformations of delta $M^4 \times CP_2$, as isometries.

Conformal symmetry of string models →the supersymplecto symmetry

Classical physics as exact part of quantum

General Coordinate Invariance : 3-surface↔space-time as 4-surface: holography

Space-time as "Bohr orbit". WCW consists of preferred extremals in inside CD.

Quantum states as superpositions of preferred extremals

Geometrization of fermions

WCW gamma matrices combinations of fermionic oscillator operators for induced spinor fields

Second quantization of induced fermions at space-time surface

Quantum states as modes of formally classical WCW spinor fields: no quant ization of WCW level!

Figure 3: Geometrization of quantum physics in terms of WCW

The associated notion of causal diamond (CD) is essential element and assigns to elementary particles new fundamental time scales which are macroscopic: for electron the time scale is .1 seconds, the fundamental biorhythm. An essentially new element is time-like entanglement which allows to understand among other things the quantum counterparts of Boolean functions in terms of time-like entanglement in fermionic degrees of freedom.

- The assignment of dark matter with a hierarchy of Planck constants gives rise to a hierarchy of macroscopic quantum phases making possible macroscopic and macrotemporal quantum coherence and allowing to understand evolution as a gradual increase of Planck constant. The model for dark nucleons leads to a surprising conclusion: the states of nucleons correspond to DNA, RNA, tRNA, and amino-acids in a natural manner and vertebrate genetic code as correspondence between DNA and amino-acids emerges naturally. This suggests that genetic code is realized at the level of dark hadron physics and living matter in the usual sense provides a secondary representation for it. The hierarchy of Planck constants emerges from basic TGD under rather general assumptions.

- p-Adic physics can be identified as physics of cognition and intentionality. Negentropic entanglement possible for number theoretic entanglement entropy makes sense for rational (and even algebraic) entanglement and leads to the identification of life as something residing in the intersection of real and p-adic worlds. NMP respects negentropic entanglement and the attractive idea is that the experience of understanding and positively colored emotions relate to negentropic entanglement.

- Living matter as conscious hologram is one of the basic ideas of TGD inspired biology and consciousness theory. The basic objection against TGD is that the interference of classical
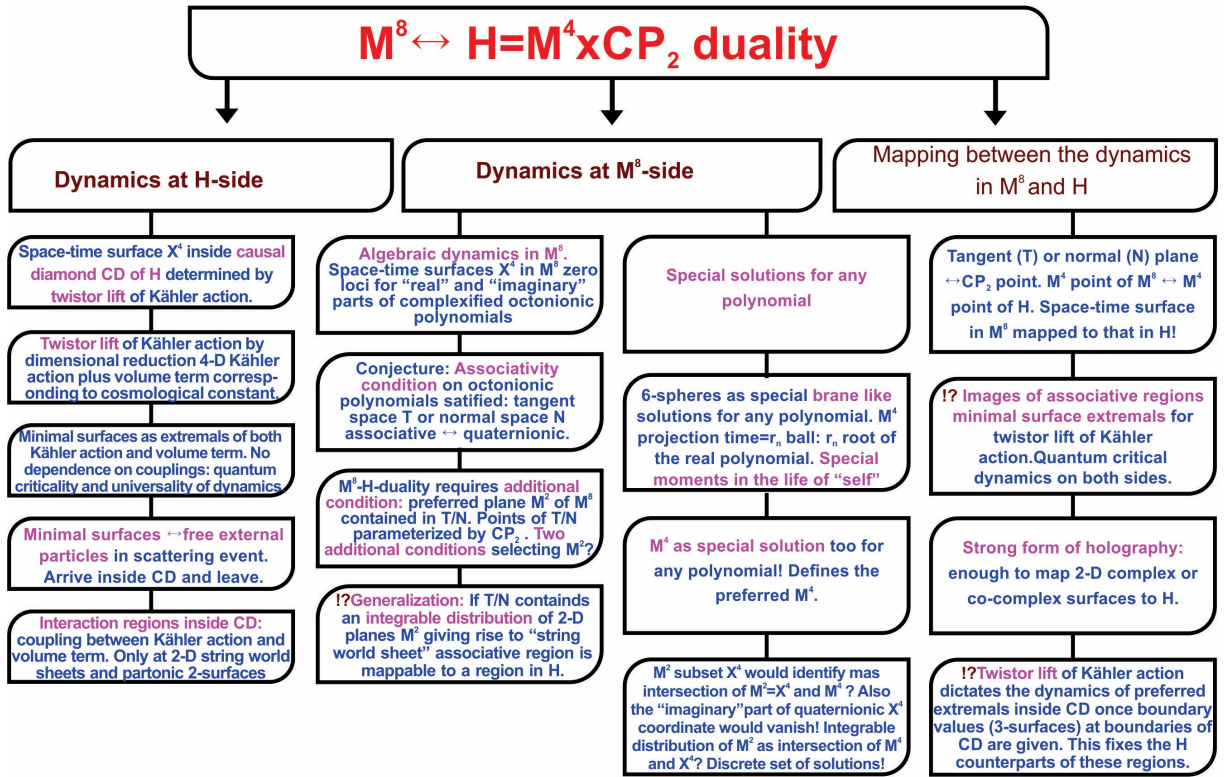
Figure 4: $M^8 - H$ duality

fields is impossible in the standard sense for the reason that that classical fields are not primary dynamical variables in TGD Universe. The resolution is based on the observation that only the interference of the effects caused by these fields can be observed experimentally and that many-sheeted space-time allows to realized the summation of effects in terms of multiple topological condensations of particles to several parallel space-time sheets. One concrete implication is fractality of qualia. Qualia appear in very wide range of scales: our qualia could in fact be those of magnetic body. The proposed mechanism for the generation of qualia realizes the fractality idea.

Various anomalies of living matter have been in vital role in the development of not only TGD view about living matter but also TGD itself.

- TGD approach to living matter was strongly motivated by the findings about the strange behavior of cell membrane and of cellular water, and gel behavior of cytoplasm. Also the findings about effects of ELF em fields on vertebrate brain were decisive and led to the proposal of the hierarchy of Planck constants found later to emerge naturally from the non-determinism of Kähler action. Rather satisfactorily, the other manner to introduce the hierarchy of Planck constants is in terms of gravitational Planck constant: at least in microscopic scales the equivalence of these approaches makes sense and leads to highly non-trivial predictions. The basic testable prediction is that dark photons have cyclotron frequencies inversely proportional to their masses but universal energy spectrum in visible and UV range which corresponds to the transition energies for biomolecules so that they are ideal for biocontrol at the level of both magnetic bodies and at the level of biochemistry.

- Water is in key role in living matter and also in TGD inspired view about living matter. The
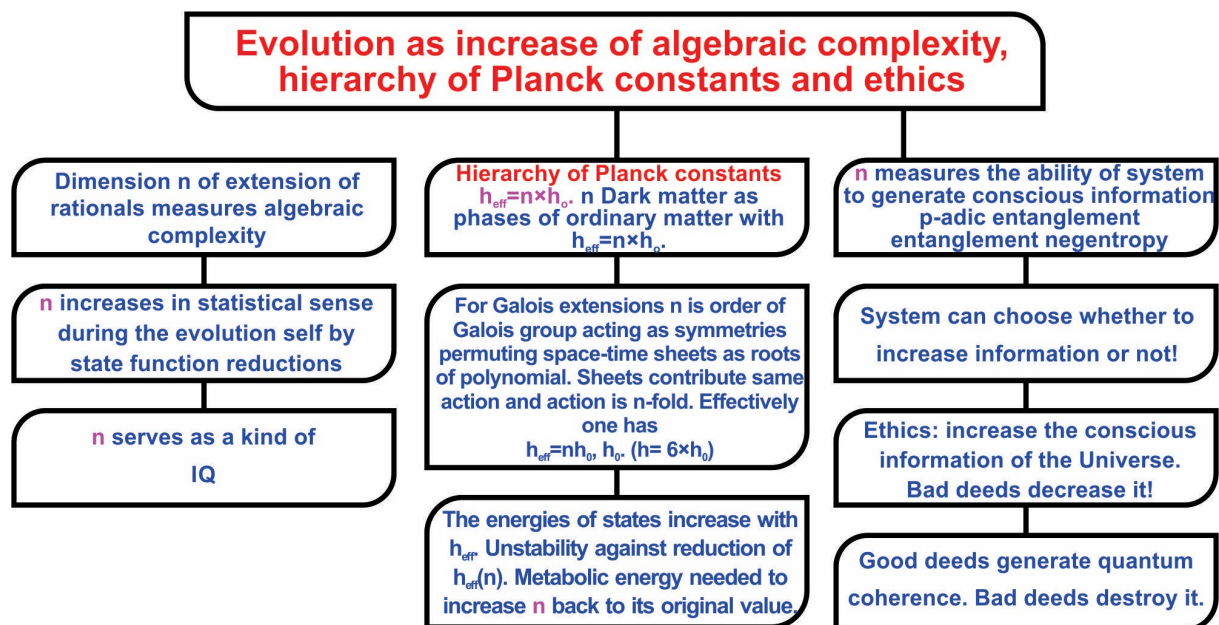
Figure 5: Number theoretic view of evolution
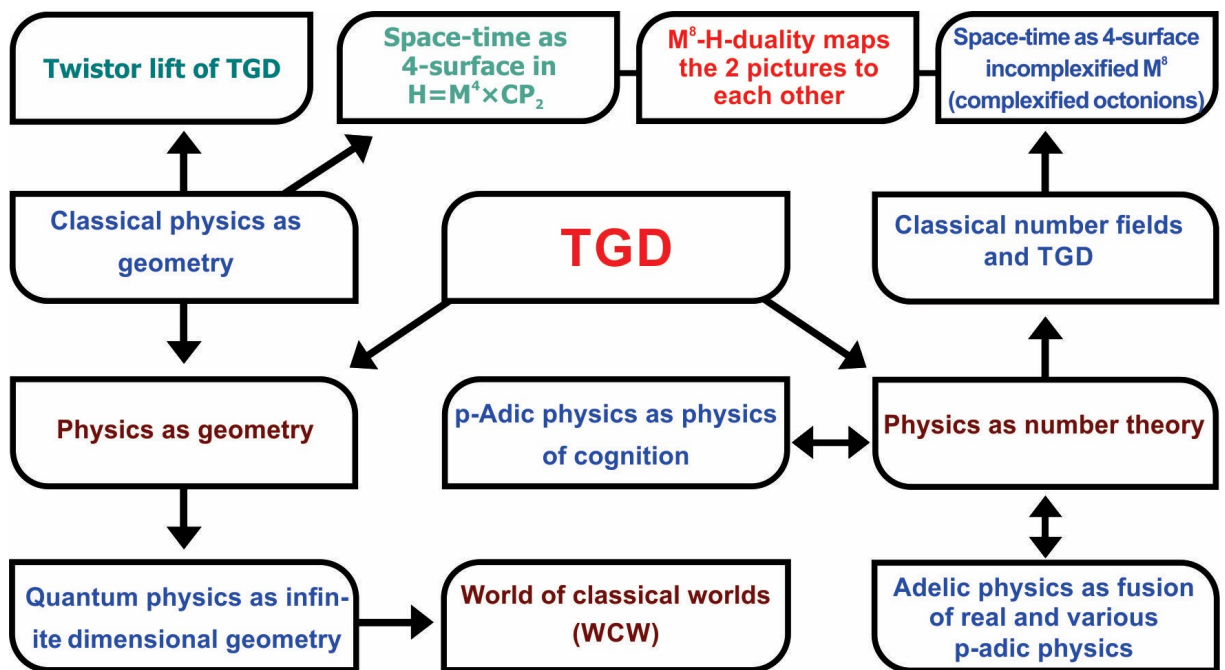
Figure 6: TGD is based on two complementary visions: physics as geometry and physics as number theory.
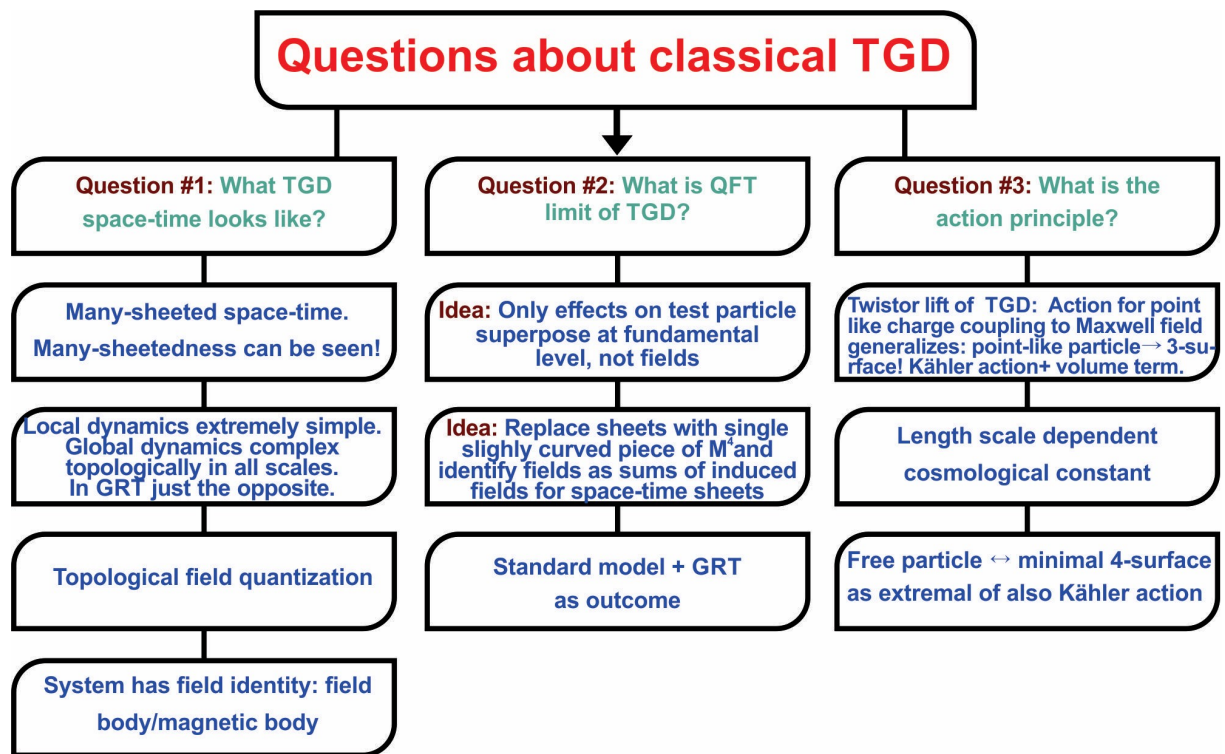
Figure 7: Questions about classical TGD.
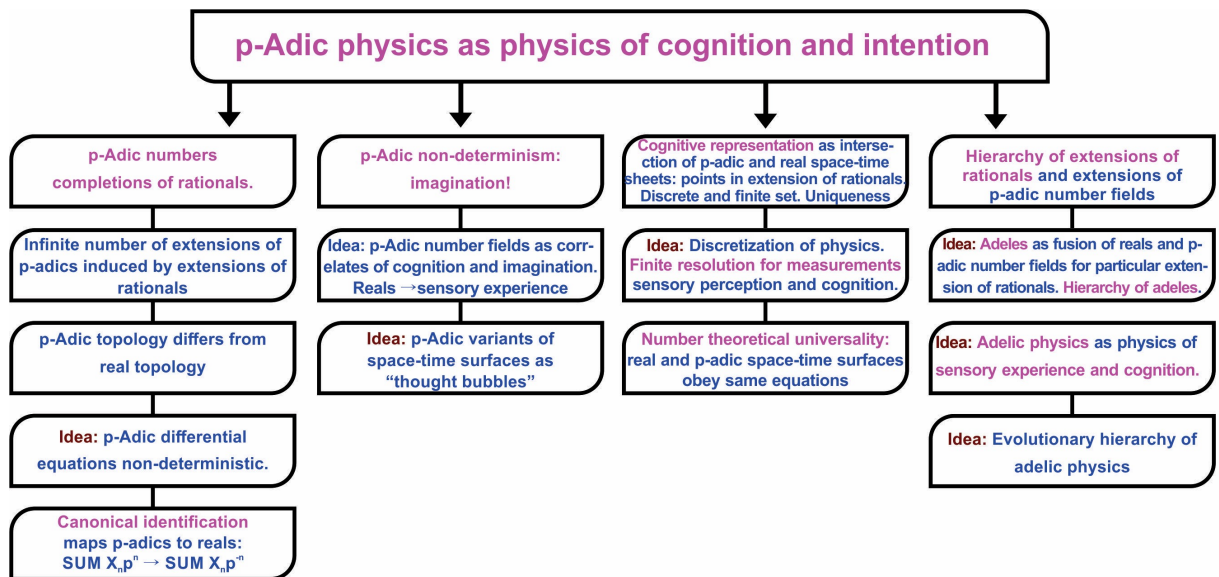
Figure 8: p-Adic physics as physics of cognition and imagination.

anomalies of water lead to a model for dark nuclei as dark proton strings with the surprising prediction that DNA, RNA, aninoacids and even tRNA are in one-one correspondence with the resulting 3-quark states and that vertebrate genetic code emerges naturally. This leads to a vision about water as primordial lifeform still playing a vital role in living organisms. The model of water memory and homeopathy in turn generalizes to a vision about how immune system might have evolved.

- Metabolic energy is necessary for conscious information processing in living matter. This suggests that metabolism should be basically tranfer of negentropic entanglement from nutrients to the organism. ATP could be seen as a molecule of consciousness in this picture and high energy phosphate bond would make possible the transfer of negentropy.

- Pollack effect and its generalizations are in a central role in the TGD inspire quantum biology. In the Pollack effect, the feed of energy allows to increase the value of effective Planck const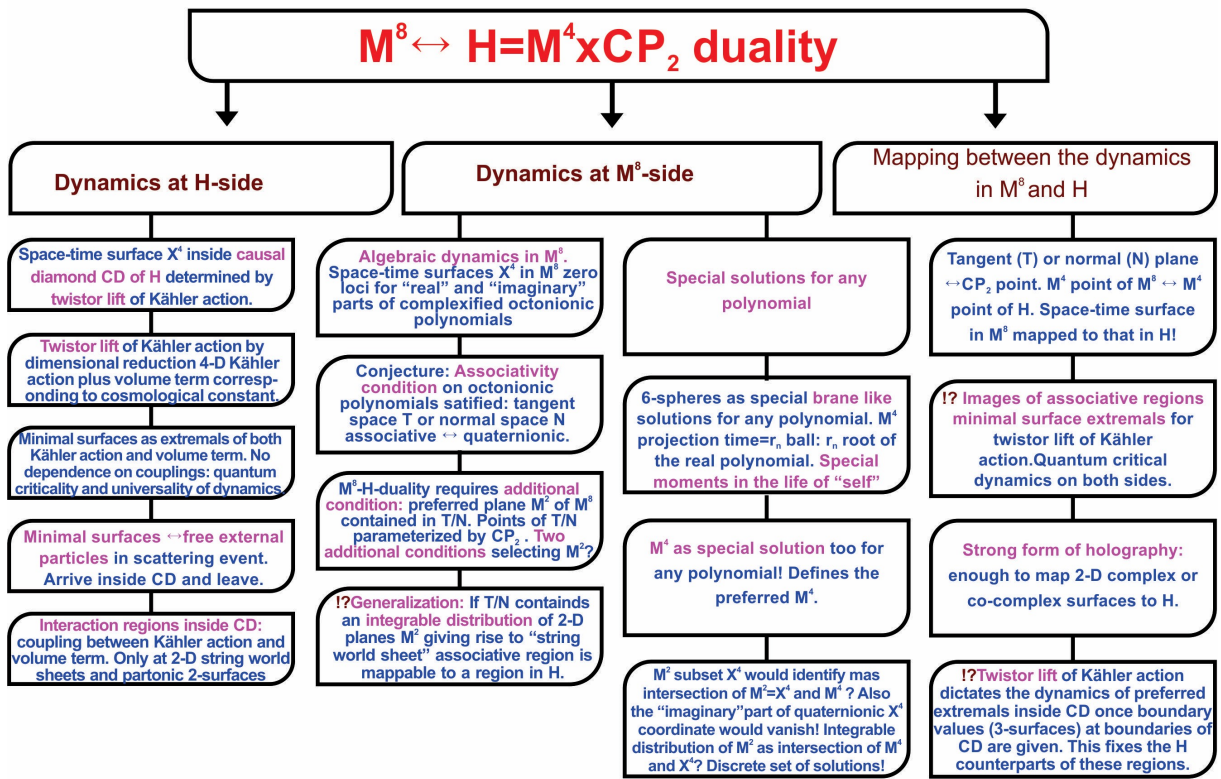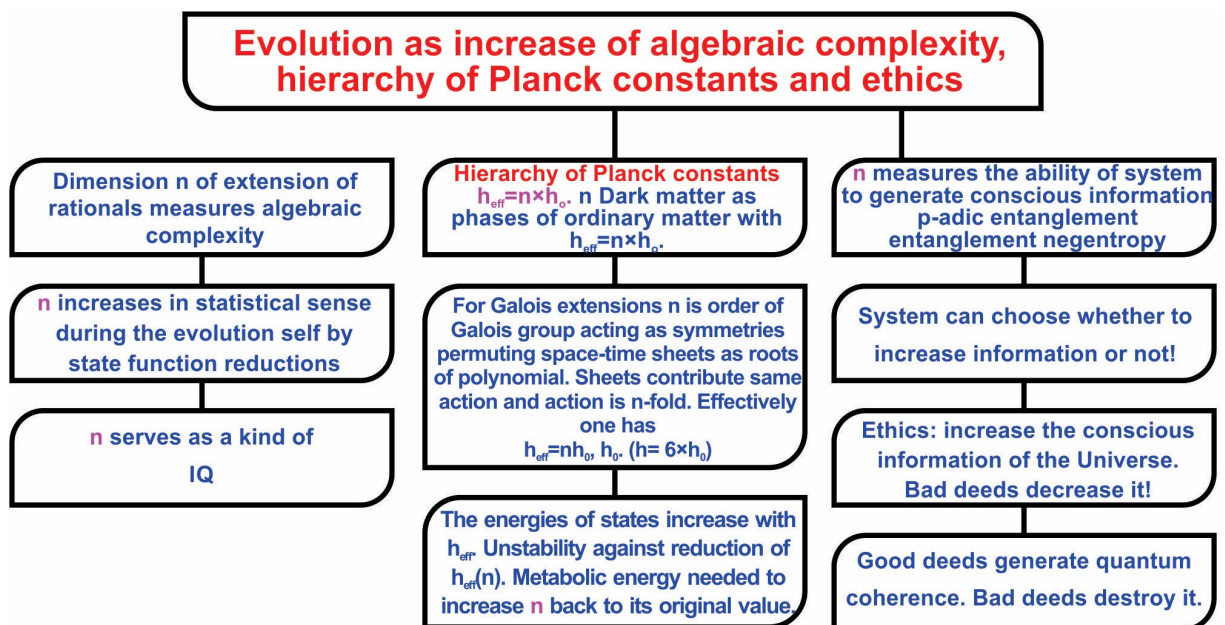ant so that an ordinary charged particle transforms to its dark variant, being kicked to, say, the gravitational magnetic body of the system itself or some other system such as the Earth or Sun. Charge separation takes place between ordinary biomatter and its magnetic body. Dissipation is extremely small at the magnetic /field body so that Pollack effect makes it possible to realize various biological functions at the magnetic/field body. Photons, in particular solar photons, can provide the energy needed to increase the value of h_{eff} but there are many other possibilities. For instance, the formation of molecular bound states of atoms liberates energy which can be used in the Pollack effect and this process could generate dark matter at the magnetic and more general field bodies.

CAUSAL DIAMOND (CD)
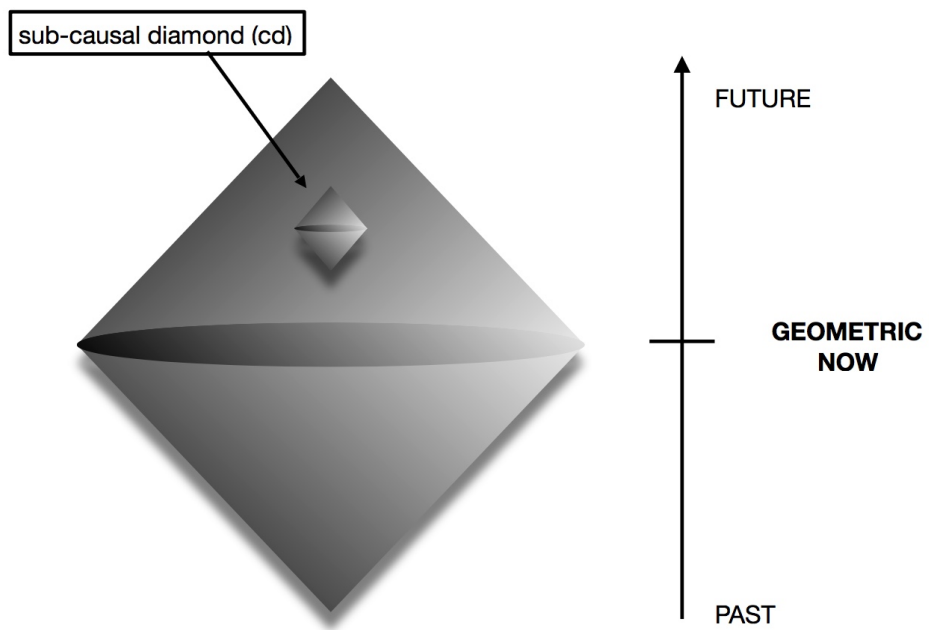
Figure 9: Causal diamond
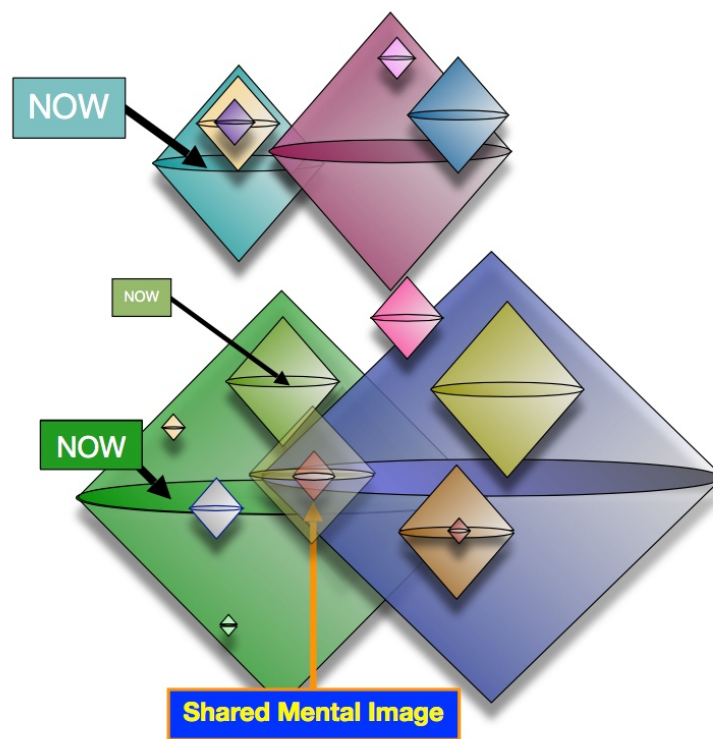
Figure 10: CDs define a fractal "conscious atlas"
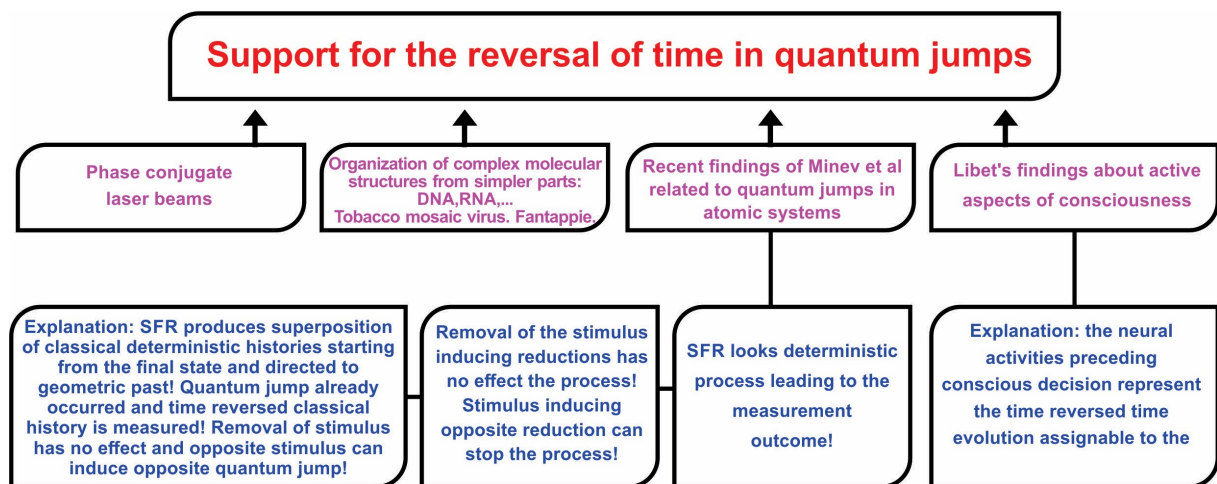
Figure 11: Time reversal occurs in BSFR

Figures
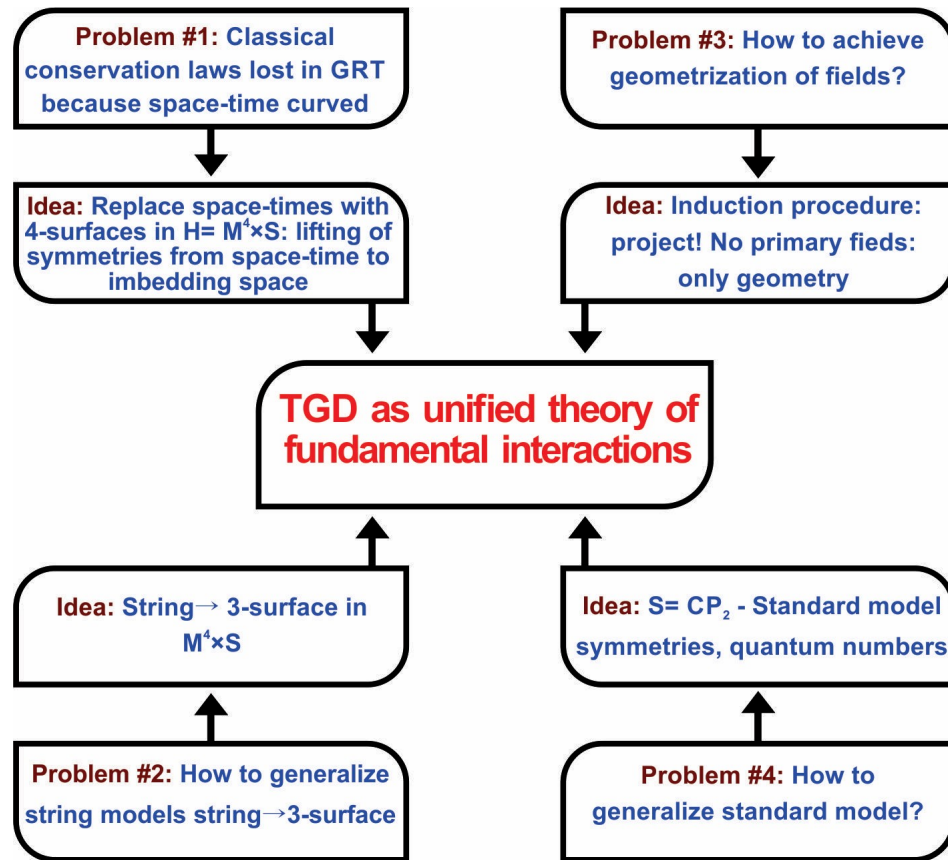
Figure 12: The problems leading to TGD as their solution.

What I have said above is strongly biased view about the recent situation in quantum TGD. This vision is single man's view and doomed to contain unrealistic elements as I know from experience. My dream is that young critical readers could take this vision seriously enough to try to demonstrate that some of its basic premises are wrong or to develop an alternative based on these or better premises. I must be however honest and tell that 45 years of TGD is a really vast bundle of thoughts and quite a challenge for anyone who is not able to cheat himself by taking the attitude of a blind believer or a light-hearted debunker trusting on the power of easy rhetoric tricks.

Karkkila, April 22, 2024, Finland

Matti Pitkänen

Figure 13: Twistor lift

Quantum TGD as geometry of "world of classical worlds" (WCW)

Geometrize entire quantum physics rather than only classical physics

Quantum physics in WCW classical physics for WCW spinor fields. Dirac equation in WCW

Zero energy ontology (ZEO). Space-time surfaces inside causal diamonds (CDs).

The existence of Kähler Geometry of infinite-D WCW makes WCW and physics unique!

Existence of Riemann connection in infinite-D contex requires maximal group of isometries. Symplectic transformations of delta $M^4 \times CP_2$, as isometries.

Conformal symmetry of string models →the supersymplecto symmetry

Classical physics as exact part of quantum

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Figure 14: Geometrization of quantum physics in terms of WCW

Figure 15: $M^8 - H$ duality

Figure 16: Number theoretic view of evolution
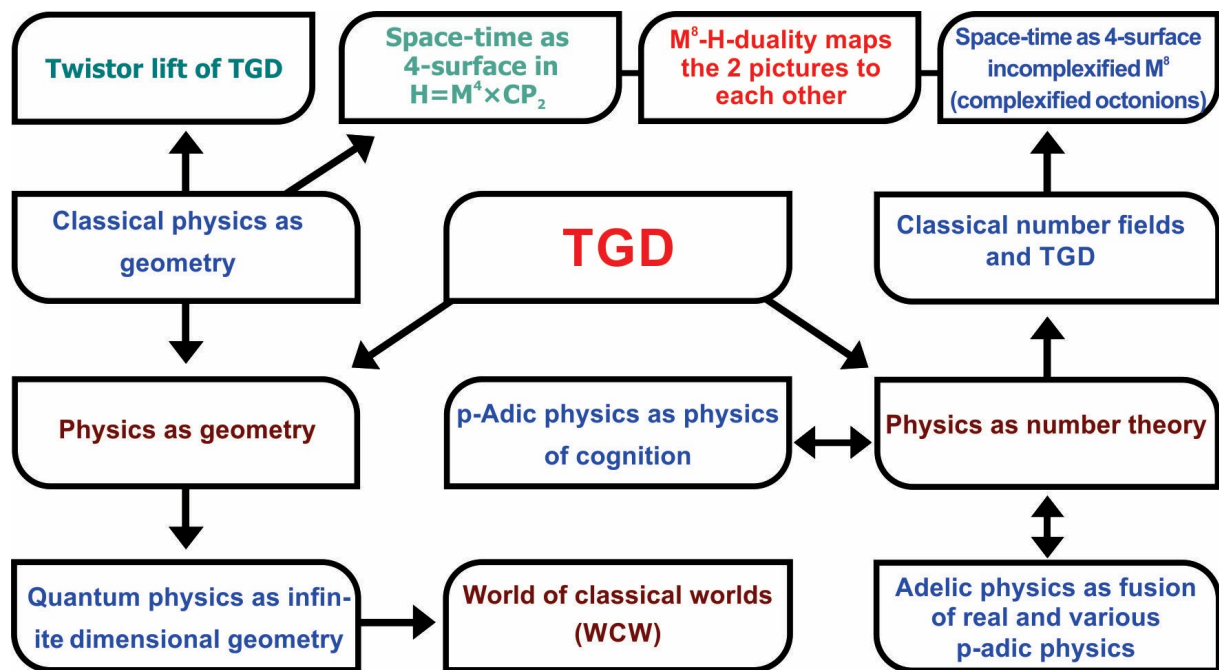
Figure 17: TGD is based on two complementary visions: physics as geometry and physics as number theory.
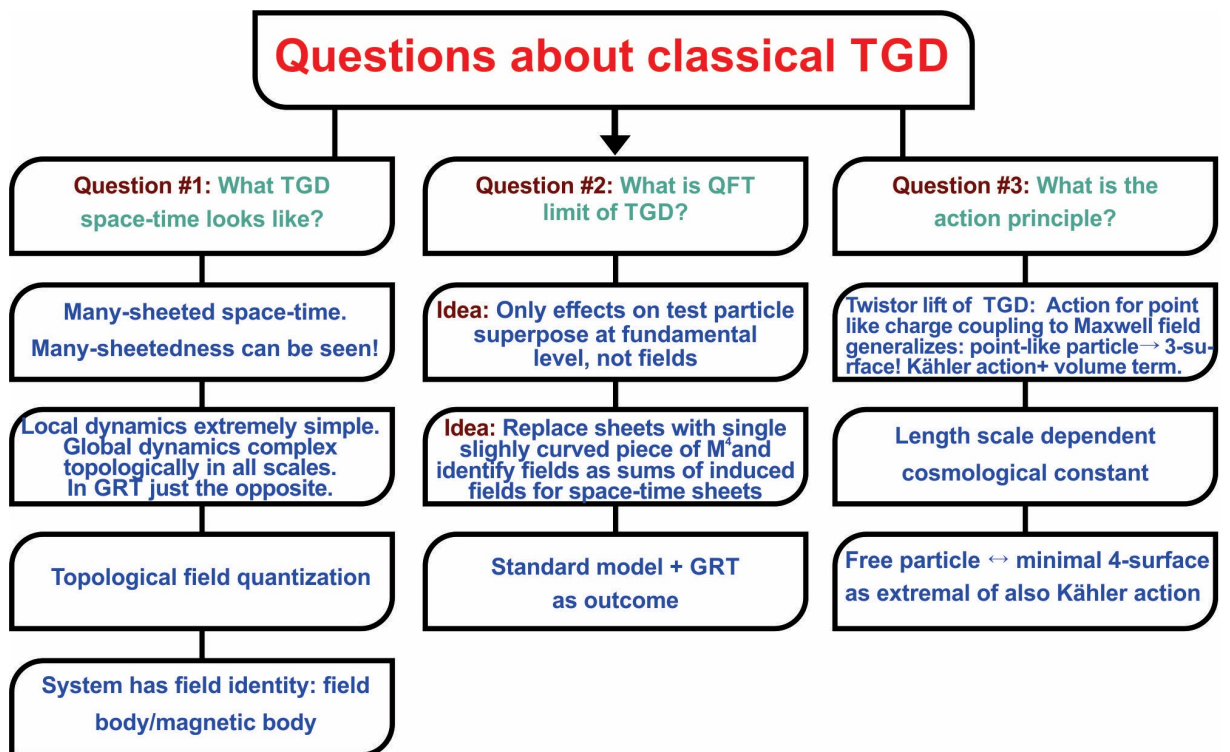
Figure 18: Questions about classical TGD.
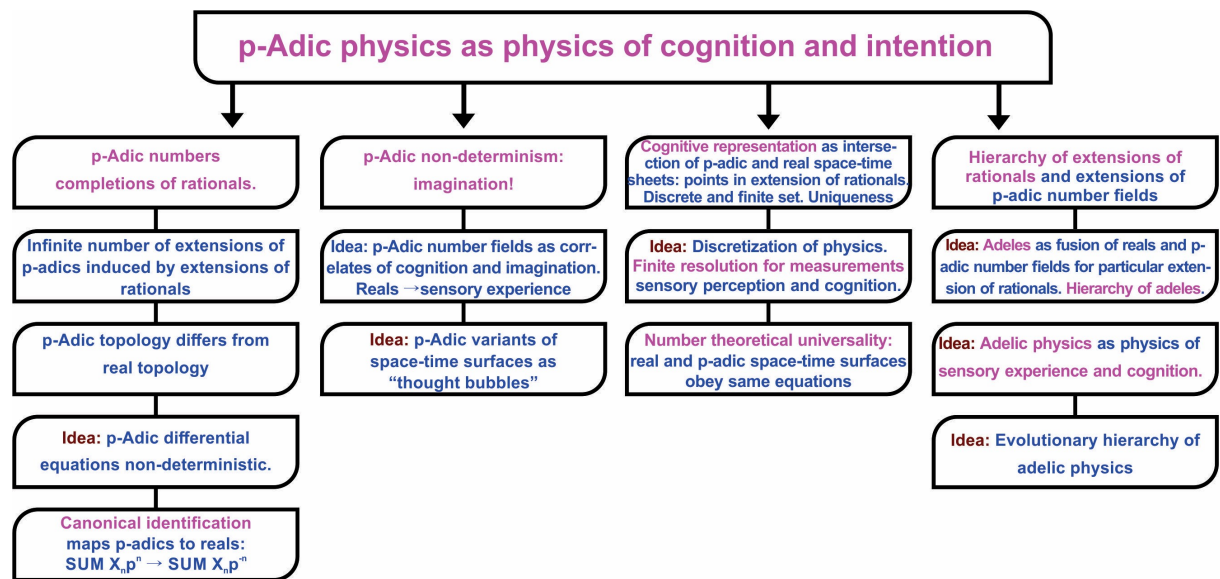
Figure 19: p-Adic physics as physics of cognition and imagination.
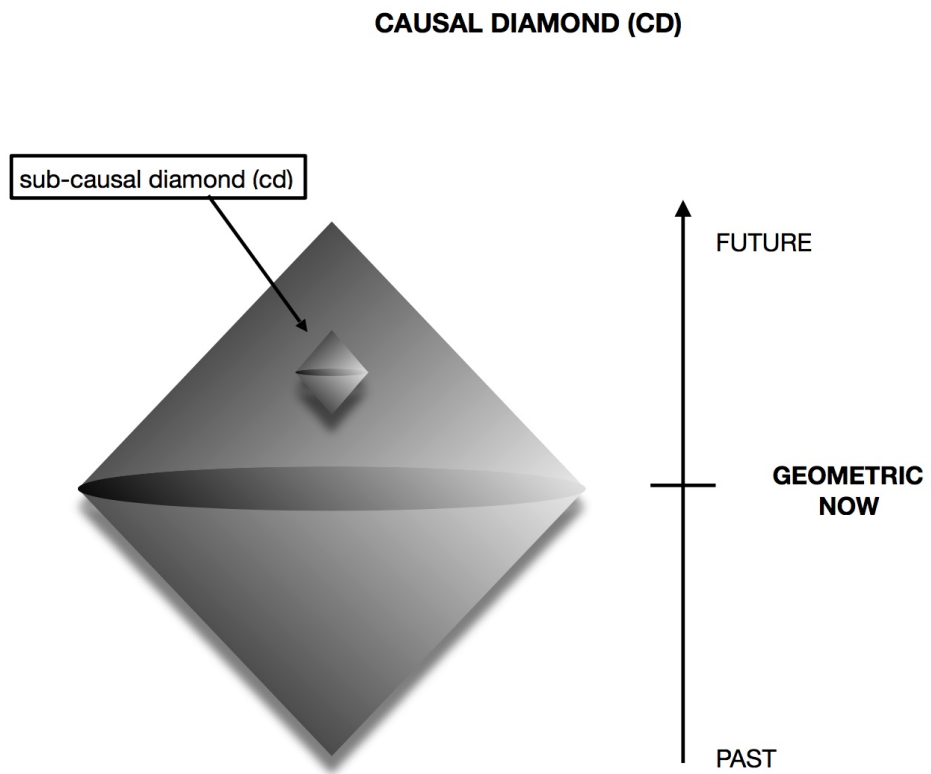
CAUSAL DIAMOND (CD)

Figure 20: Causal diamond
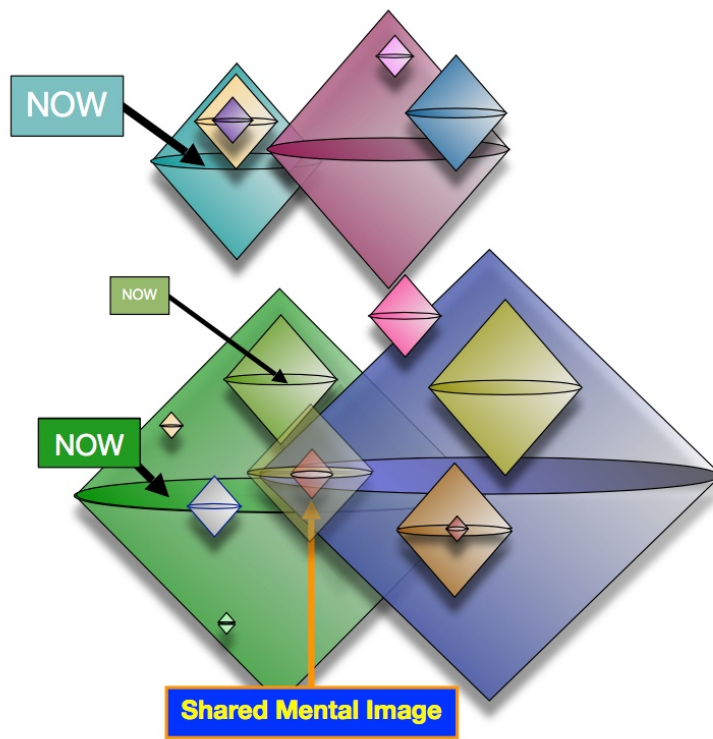
Figure 21: CDs define a fractal "conscious atlas"

Support for the reversal of time in quantum jumps

| Phase conjugate laser beams | Organization of complex molecular structures from simpler parts: DNA,RNA,... Tobacco mosaic virus. Fantappie. | Recent findings of Minev et al related to quantum jumps in atomic systems | Libet's findings about active aspects of consciousness |

Explanation: SFR produces superposition of classical deterministic histories starting from the final state and directed to geometric past! Quantum jump already occurred and time reversed classical history is measured! Removal of stimulus has no effect and opposite stimulus can induce opposite quantum jump!

Removal of the stimulus inducing reductions has no effect the process! Stimulus inducing opposite reduction can stop the process!

SFR looks deterministic process leading to the measurement outcome!

Explanation: the neural activities preceding conscious decision represent the time reversed time evolution assignable to the

Figure 22: Time reversal occurs in BSFR

ACKNOWLEDGEMENTS

Phil Gibbs, and Arkadiusz Jadczyk deserve my gratitude for their kind help in the preparation of an article series about TGD catalyzing a considerable progress in the understanding of quantum TGD. Also the viXra archive founded by Phil Gibbs and its predecessor Archive Freedom have been of great help: Victor Christianto deserves special thanks for doing the hard work needed to run Archive Freedom. Also the Neuroquantology Journal founded by Sultan Tarlaci deserves a special mention for its publication policy.

And last but not least: there are people who experience as a fascinating intellectual challenge to spoil the practical working conditions of a person working with something which might be called unified theory: I am grateful for the people who have helped me to survive through the virus attacks, an activity which has taken roughly one month per year during the last half decade and given a strong hue of grey to my hair.

For a person approaching his 73th birthday it is somewhat easier to overcome the hard feelings due to the loss of academic human rights than for an inpatient youngster. Unfortunately the economic situation has become increasingly difficult during the twenty years after the economic depression in Finland which in practice meant that Finland ceased to be a constitutional state in the strong sense of the word. It became possible to depose people like me from society without fear about public reactions and the classification as dropout became a convenient tool of ridicule to circumvent the ethical issues. During the period when the right wing held political power this trend was steadily strengthening and the situation is the same as I am writing this. In this kind of situation the concrete help from individuals has been and will be of utmost importance. Against this background it becomes obvious that this kind of work is not possible without the support from outside and I apologize for not being able to mention all the people who have helped me during these years.

Karkkila, August 30, 2023, Finland

Matti Pitkänen

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Chapter 1

Introduction

1.1 Basic Ideas of Topological Geometrodynamics (TGD)

Standard model describes rather successfully both electroweak and strong interactions but sees them as totally separate and contains a large number of parameters which it is not able to predict. For about four decades ago unified theories known as Grand Unified Theories (GUTs) trying to understand electroweak interactions and strong interactions as aspects of the same fundamental gauge interaction assignable to a larger symmetry group emerged. Later superstring models trying to unify even gravitation and strong and weak interactions emerged. The shortcomings of both GUTs and superstring models are now well-known. If TGD - whose basic idea emerged towards the end of 1977 - would emerge now it would be seen as an attempt to solve the difficulties of these approaches to unification.

The basic physical picture   behind the geometric vision of TGD corresponds to a fusion of two rather disparate approaches: namely   TGD   as a Poincare invariant theory of gravitation and TGD as a generalization of the old-fashioned string model. After 1995 number theoretic vision started to develop and was initiated by the success of mass calculations based on p-adic thermodynamics. Number theoretic vision involves all number fields and is complementary to the geometric vision: one can say that this duality is analogous to momentum-position duality of wave mechanics.   TGD can be also regarded as topological quantum theory in a very general sense as already the attribute "Topological" in "TGD" makes clear. Space-time surfaces as minimal surfaces can be regarded as representatives of homology equivalence classes and p-adic topologies generalize the notion of local topology and apply to the description of correlates of cognition.

1.1.1 Geometric Vision Very Briefly

T(opological) G(eometro)D(ynamics)   is one of the many attempts to find a unified description of basic interactions. The development of the basic ideas of TGD to a relatively stable form took time of about half decade [K3].

The basic vision and its relationship to existing theories is now rather well understood.

1. Space-times are representable as 4-surfaces in the 8-dimensional embedding space $H = M^4 \times CP_2$, where M^4 is 4-dimensional (4-D) Minkowski space and CP_2 is 4-D complex projective space (see Appendix).

2. Induction procedure (a standard procedure in fiber bundle theory, see Appendix) allows to geometrize various fields. Space-time metric characterizing gravitational fields corresponds to the induced metric obtained by projecting the metric tensor of H to the space-time surface. Electroweak gauge potentials are identified as projections of the components of CP_2 spinor connection to the space-time surface, and color gauge potentials as projections of CP_2 Killing vector fields representing color symmetries. Also spinor structure can be induced: induced spinor gamma matrices are projections of gamma matrices of H and induced spinor fields just H spinor fields restricted to space-time surface. Spinor connection is also projected. The interpretation is that distances are measured in embedding space metric and parallel translation using spinor connection of embedding space.

Twistor lift of TGD means that one can lift space-time surfaces in H to 6-D surfaces a analogs of twistor space of space-time surface in the Cartesian product of the twistor spaces of M^4 and CP_2, which are the only 4-manifolds allowing twistor space with Kähler structure [A17]. The twistor structure would be induced in some sense, and should coincide with that associated with the induced metric. Clearly, the 2-spheres defining the fibers of twistor spaces of M^4 and CP_2 must allow identification: this 2-sphere defines the S^2 fiber of the twistor space of the space-time surface. This poses a constraint on the embedding of the twistor space of space-time surfaces as sub-manifold in the Cartesian product of twistor spaces. The existence of Kähler structure allows to lift 4-D Kähler action to its 6-D counterparts and the 6-D counterpart of twistor space is obtained by its dimensional reduction so that one obtains a sphere bundle. This makes possible twistorialization for all space-time surfaces: in general relativity the general metric does not allow this.

3. A geometrization of quantum numbers is achieved. The isometry group of the geometry of CP_2 codes for the color gauge symmetries of strong interactions. Vierbein group codes for electroweak symmetries, and explains their breaking in terms of CP_2 geometry so that standard model gauge group results. There are also important deviations from the standard model: color quantum numbers are not spin-like but analogous to orbital angular momentum: this difference is expected to be seen only in CP_2 scale. In contrast to GUTs, quark and lepton numbers are separately conserved and family replication has a topological explanation in terms of topology of the partonic 2-surface carrying fermionic quantum numbers.

   M^4 and CP_2 are unique choices for many other reasons. For instance, they are the unique 4-D space-times allowing twistor space with Kähler structure. M^4 light-cone boundary allows a huge extension of 2-D conformal symmetries. M^4 and CP_2 allow quaternionic structures. Therefore standard model symmetries have number theoretic meaning.

4. Induced gauge potentials are expressible in terms of embedding space coordinates and their gradients and general coordinate invariance implies that there are only 4 field-like variables locally. Situation is thus extremely simple mathematically. The objection is that one loses linear superposition of fields. The resolution of the problem comes from the generalization of the concepts of particle and space-time.

   Space-time surfaces can be also particle like having thus finite size. In particular, space-time regions with Euclidian signature of the induced metric (temporal and spatial dimensions in the same role) emerge and have interpretation as lines of generalized Feynman diagrams. Particles in space-time can be identified as a topological inhomogeneities in background space-time surface which looks like the space-time of general relativity in long length scales.

   One ends up with a generalization of space-time surface to many-sheeted space-time with space-time sheets having extremely small distances of about 10^4 Planck lengths (CP_2 size). As one adds a particle to this kind of structure, it touches various space-time sheets and thus interacts with the associated classical fields. Their effects superpose linearly in good approximation and linear superposition of fields is replaced with that for their effects.

   This resolves the basic objection. It also leads to the understanding of how the space-time of general relativity and quantum field theories emerges from TGD space-time as effective space-time when the sheets of many-sheeted space-time are lumped together to form a region of Minkowski space with metric replaced with a metric identified as the sum of empty Minkowski metric and deviations of the metrics of sheets from empty Minkowski metric. Gauge potentials are identified as sums of the induced gauge potentials. TGD is therefore a microscopic theory from which the standard model and general relativity follow as a topological simplification, however forcing a dramatic increase of the number of fundamental field variables.

5. A further objection is that classical weak fields identified as induced gauge fields are long ranged and should cause large parity breaking effects due to weak interactions. These effects are indeed observed but only in living matter. The basic problem is that one has long ranged classical electroweak gauge fields. The resolution of the problem is that the quantum averages of induced weak and color gauge fields vanish due to the fact that color rotations affect both space-time surfaces and induced weak and color fields. Only the averages of

electromagnetic fields are nonvanishing. The correlations functions for weak fields are non-vanishing below Compton lengths of weak bosons. In living matter large values of effective Planck constant labelling phases of ordinary matter identified as dark matter make possible long ranged weak fields and color fields.

6. General coordinate invariance requires holography so that space-time surfaces are analogous to Bohr orbits for particles identified as 3-surfaces. Bohr orbit property would be naturally realized by a 4-D generalization of holomorphy of string world sheets and implies that the space-time surfaces are minimal surfaces apart from singularities. This holds true for any action as long as it is general coordinate invariant and constructible in terms of the induced geometry. String world sheets and light-like orbits of partonic 2-surfaces correspond to singularities at which the minimal surface property of the space-time surfaces realizing the preferred extremal property fails. Preferred extremals are not completely deterministic, which implies what I call zero energy ontology (ZEO) meaning that the Bohr orbits are the fundamental objects. This leads to a solution of the basic paradox of quantum measurement theory. Also the mathematically ill-defined path integral disappears and leaves only the well-defined functional integral over the Bohr orbits.

7. A string model-like picture emerges from TGD and one ends up with a rather concrete view about the topological counterpart of Feynman diagrammatics. The natural stringy action would be given by the string world sheet area, which is present only in the space-time regions with Minkowskian signature. Gravitational constant could be present as a fundamental constant in string action and the ratio $\hbar/G/R^2$ would be determined by quantum criticality conditions. The hierarchy of Planck constants $h_{eff}/h = n$ assigned to dark matter in TGD framework would allow to circumvent the objection that only objects of length of order Planck length are possible since string tension given by $T = 1/\hbar_{eff}G$ apart from numerical factor could be arbitrary small. This would make possible gravitational bound states as partonic 2-surfaces as structures connected by strings and solve the basic problem of superstring theories. This option allows the natural interpretation of M^4 type vacuum extremals with CP_2 projection, which is Lagrange manifold as good approximations for space-time sheets at macroscopic length scales. String area does not contribute to the Kähler function at all.

Whether induced spinor fields associated with Kähler-Dirac action and de-localized inside the entire space-time surface should be allowed remains an open question: super-conformal symmetry strongly suggests their presence. A possible interpretation for the corresponding spinor modes could be in terms of dark matter, sparticles, and hierarchy of Planck constants.

It is perhaps useful to make clear what TGD is not and also what new TGD can give to physics.

1. TGD is *not* just General Relativity made concrete by using embeddings: the 4-surface property is absolutely essential for unifying standard model physics with gravitation and to circumvent the incurable conceptual problems of General Relativity. The many-sheeted space-time of TGD gives rise only at the macroscopic limit to GRT space-time as a slightly curved Minkowski space. TGD is *not* a Kaluza-Klein theory although color gauge potentials are analogous to gauge potentials in these theories.

   TGD space-time is 4-D and its dimension is due to completely unique conformal properties of light-cone boundary and 3-D light-like surfaces implying enormous extension of the ordinary conformal symmetries. Light-like 3-surfaces represent orbits of partonic 2-surfaces and carry fundamental fermions at 1-D boundaries of string world sheets. TGD is *not* obtained by performing Poincare gauging of space-time to introduce gravitation and is plagued by profound conceptual problems.

2. TGD is *not* a particular string model although string world sheets emerge in TGD very naturally as loci for spinor modes: their 2-dimensionality makes among other things possible quantum deformation of quantization known to be physically realized in condensed matter, and conjectured in TGD framework to be crucial for understanding the notion of finite measurement resolution. Hierarchy of objects of dimension up to 4 emerge from TGD: this obviously means analogy with branes of super-string models.

TGD is *not* one more item in the collection of string models of quantum gravitation relying on Planck length mystics. Dark matter becomes an essential element of quantum gravitation and quantum coherence in astrophysical scales is predicted just from the assumption that strings connecting partonic 2-surfaces are responsible for gravitational bound states.

TGD is *not* a particular string model although AdS/CFT duality of super-string models generalizes due to the huge extension of conformal symmetries and by the identification of WCW gamma matrices as Noether super-charges of super-symplectic algebra having a natural conformal structure.

3. TGD is *not* a gauge theory. In TGD framework the counterparts of also ordinary gauge symmetries are assigned to super-symplectic algebra (and its Yangian [A3] [B13, B11, B12]), which is a generalization of Kac-Moody algebras rather than gauge algebra and suffers a fractal hierarchy of symmetry breakings defining hierarchy of criticalities. TGD is *not* one more quantum field theory like structure based on path integral formalism: path integral is replaced with functional integral over 3-surfaces, and the notion of classical space-time becomes an exact part of the theory. Quantum theory becomes formally a purely classical theory of WCW spinor fields: only state function reduction is something genuinely quantal.

4. TGD view about spinor fields is *not* the standard one. Spinor fields appear at three levels. Spinor modes of the embedding space are analogs of spinor modes characterizing incoming and outgoing states in quantum field theories. Induced second quantized spinor fields at space-time level are analogs of stringy spinor fields. Their modes are localized by the well-definedness of electro-magnetic charge and by number theoretic arguments at string world sheets. Kähler-Dirac action is fixed by supersymmetry implying that ordinary gamma matrices are replaced by what I call Kähler-Dirac gamma matrices - this something new. WCW spinor fields, which are classical in the sense that they are not second quantized, serve as analogs of fields of string field theory and imply a geometrization of quantum theory.

5. TGD is in some sense an extremely conservative geometrization of entire quantum physics: *no* additional structures such as gauge fields as independent dynamical degrees of freedom are introduced: Kähler geometry and associated spinor structure are enough. "Topological" in TGD should not be understood as an attempt to reduce physics to torsion (see for instance [B10]) or something similar. Rather, TGD space-time is topologically non-trivial in all scales and even the visible structures of the everyday world represent non-trivial topology of space-time in the TGD Universe.

6. Twistor space - or rather, a generalization of twistor approach replacing masslessness in 4-D sense with masslessness in 8-D sense and thus allowing description of also massive particles - emerged originally as a technical tool, and its Kähler structure is possible only for $H = M^4 \times CP_2$. It however turned out that much more than a technical tool is in question. What is genuinely new is the infinite-dimensional character of the Kähler geometry making it highly unique, and its generalization to p-adic number fields to describe correlates of cognition. Also the hierarchy of Planck constants $h_{eff} = n \times h$ reduces to the quantum criticality of the TGD Universe and p-adic length scales and Zero Energy Ontology represent something genuinely new.

The great challenge is to construct a mathematical theory around these physically very attractive ideas and I have devoted the last 45 years to the realization of this dream and this has resulted in 26 online books about TGD and nine online books about TGD inspired theory of consciousness and of quantum biology.

A collection of 30 online books is now (August 2023) under preparation. The goal is to minimize overlap between the topics of the books and make the focus of a given book sharper.

1.1.2   Two Visions About TGD as Geometrization of Physics and Their Fusion

As already mentioned, TGD as a geometrization of physics can be interpreted both as a modification of general relativity and generalization of string models.

TGD as a Poincare Invariant Theory of Gravitation

The first approach was born as an attempt to construct a Poincare invariant theory of gravitation. Space-time, rather than being an abstract manifold endowed with a pseudo-Riemannian structure, is regarded as a surface in the 8-dimensional space $H = M^4_\times CP_2$, where M^4 denotes Minkowski space and $CP_2 = SU(3)/U(2)$ is the complex projective space of two complex dimensions [A13, A16, A11, A15].

The identification of the space-time as a sub-manifold [A14, A19] of $M^4 \times CP_2$ leads to an exact Poincare invariance and solves the conceptual difficulties related to the definition of the energy-momentum in General Relativity.

It soon however turned out that sub-manifold geometry, being considerably richer in structure than the abstract manifold geometry, leads to a geometrization of all basic interactions. First, the geometrization of the elementary particle quantum numbers is achieved. The geometry of CP_2 explains electro-weak and color quantum numbers. The different H-chiralities of H-spinors correspond to the conserved baryon and lepton numbers. Secondly, the geometrization of the field concept results. The projections of the CP_2 spinor connection, Killing vector fields of CP_2 and of H-metric to four-surface define classical electro-weak, color gauge fields and metric in X^4.

The choice of H is unique from the condition that TGD has standard model symmetries. Also number theoretical vision selects $H = M^4 \times CP_2$ uniquely. M^4 and CP_2 are also unique spaces allowing twistor space with Kähler structure.

TGD as a Generalization of the Hadronic String Model

The second approach was based on the generalization of the mesonic string model describing mesons as strings with quarks attached to the ends of the string. In the 3-dimensional generalization 3-surfaces correspond to free particles and the boundaries of the 3- surface correspond to partons in the sense that the quantum numbers of the elementary particles reside on the boundaries. Various boundary topologies (number of handles) correspond to various fermion families so that one obtains an explanation for the known elementary particle quantum numbers. This approach leads also to a natural topological description of the particle reactions as topology changes: for instance, two-particle decay corresponds to a decay of a 3-surface to two disjoint 3-surfaces.

This decay vertex does not however correspond to a direct generalization of trouser vertex of string models. Indeed, the important difference between TGD and string models is that the analogs of string world sheet diagrams do not describe particle decays but the propagation of particles via different routes. Particle reactions are described by generalized Feynman diagrams for which 3-D light-like surface describing particle propagating join along their ends at vertices. As 4-manifolds the space-time surfaces are therefore singular like Feynman diagrams as 1-manifolds.

Quite recently, it has turned out that fermionic strings inside space-time surfaces define an exact part of quantum TGD and that this is essential for understanding gravitation in long length scales. Also the analog of AdS/CFT duality emerges in that the Kähler metric can be defined either in terms of Kähler function identifiable as Kähler action assignable to Euclidian space-time regions or Kähler action + string action assignable to Minkowskian regions.

The recent view about construction of scattering amplitudes is very "stringy". By strong form of holography string world sheets and partonic 2-surfaces provide the data needed to construct scattering amplitudes. Space-time surfaces are however needed to realize quantum-classical correspondence necessary to understand the classical correlates of quantum measurement. There is a huge generalization of the duality symmetry of hadronic string models.

The proposal is that scattering amplitudes can be regarded as sequences of computational operations for the Yangian of super-symplectic algebra. Product and co-product define the basic vertices and realized geometrically as partonic 2-surfaces and algebraically as multiplication for the elements of Yangian identified as super-symplectic Noether charges assignable to strings. Any computational sequences connecting given collections of algebraic objects at the opposite boundaries of causal diamond (CD) produce identical scattering amplitudes.

Fusion of the Two Approaches via a Generalization of the Space-Time Concept

The problem is that the two approaches to TGD seem to be mutually exclusive since the orbit of a particle like 3-surface defines 4-dimensional surface, which differs drastically from the topologically

trivial macroscopic space-time of General Relativity. The unification of these approaches forces a considerable generalization of the conventional space-time concept. First, the topologically trivial 3-space of General Relativity is replaced with a "topological condensate" containing matter as particle like 3-surfaces "glued" to the topologically trivial background 3-space by connected sum operation. Secondly, the assumption about connectedness of the 3-space is given up. Besides the "topological condensate" there could be "vapor phase" that is a "gas" of particle like 3-surfaces and string like objects (counterpart of the "baby universes" of GRT) and the non-conservation of energy in GRT corresponds to the transfer of energy between different sheets of the space-time and possible existence vapour phase.

. What one obtains is what I have christened as many-sheeted space-time (see **Fig. http://tgdtheory.fi/appfigures/manysheeted.jpg** or **Fig. ??** in the appendix of this book). One particular aspect is topological field quantization meaning that various classical fields assignable to a physical system correspond to space-time sheets representing the classical fields to that particular system. One can speak of the field body of a particular physical system. Field body consists of topological light rays, and electric and magnetic flux quanta. In Maxwell's theory the physical system does not possess this kind of field identity. The notion of the magnetic body is one of the key players in TGD inspired theory of consciousness and quantum biology. The existence of monopole flux tubes requiring no current as a source of the magnetic field makes it possible to understand the existence of magnetic fields in cosmological and astrophysical scales.

This picture became more detailed with the advent of zero energy ontology (ZEO). The basic notion of ZEO is causal diamond (CD) identified as the Cartesian product of CP_2 and of the intersection of future and past directed light-cones and having scale coming as an integer multiple of CP_2 size is fundamental. CDs form a fractal hierarchy and zero energy states decompose to products of positive and negative energy parts assignable to the opposite boundaries of CD defining the ends of the space-time surface. The counterpart of zero energy state in positive energy ontology is the pair of initial and final states of a physical event, say particle reaction.

At space-time level ZEO means that 3-surfaces are pairs of space-like 3-surfaces at the opposite light-like boundaries of CD. Since the extremals of Kähler action connect these, one can say that by holography the basic dynamical objects are the space-time surface connecting these 3-surfaces and identifiable as analogs of Bohr orbits. This changes totally the vision about notions like self-organization: self-organization by quantum jumps does not take for a 3-D system but for the entire 4-D field pattern associated with it.

General Coordinate Invariance (GCI) allows to identify the basic dynamical objects as space-like 3-surfaces at the ends of space-time surface at boundaries of CD: this means that space-time surface is analogous to Bohr orbit. An alternative identification of the lines of generalized Feynman diagrams is as light-like 3-surfaces at which the signature of the induced metric changes from Minkowskian to Euclidian . Also the Euclidian 4-D regions can have a similar interpretation. The requirement that the two interpretations are equivalent, leads to a strong form of General Coordinate Invariance. The outcome is effective 2-dimensionality stating that the partonic 2-surfaces identified as intersections of the space-like ends of space-time surface and light-like wormhole throats are the fundamental objects. That only effective 2-dimensionality is in question is due to the effects caused by the failure of strict determinism of Kähler action. In finite length scale resolution these effects can be neglected below UV cutoff and above IR cutoff. One can also speak about a strong form of holography.

The understanding of the super symplectic invariance leads to the proposal that super symplectic algebra and other Kac-Moody type algebras labelled by non-negative multiples of basic conformal weights allow a hierarchy of symmetry breakings in which the analog of gauge symmetry breaks down to a genuine dynamical symmetry. This gives rise to fractal hierarchies of algebras and symmetry breakings. This breaking can occur also for ordinary conformal algebras if one restricts the conformal weights to be non-negative integers.

1.1.3 Basic Objections

Objections are the most powerful tool in theory building. The strongest objection against TGD is the observation that all classical gauge fields are expressible in terms of four embedding space coordinates only- essentially CP_2 coordinates. The linear superposition of classical gauge fields taking place independently for all gauge fields is lost. This would be a catastrophe without many-

sheeted space-time. Instead of gauge fields, only the effects such as gauge forces are superposed. Particles topologically condense to several space-time sheets simultaneously and experience the sum of gauge forces. This transforms the weakness to extreme economy: in a typical unified theory the number of primary field variables is countered in hundreds if not thousands, now it is just four.

Second objection is that TGD space-time is quite too simple as compared to GRT space-time due to the embeddability to 8-D embedding space. One can also argue that Poincare invariant theory of gravitation cannot be consistent with General Relativity. The above interpretation makes it possible to understand the relationship to GRT space-time and how the Equivalence Principle (EP) follows from Poincare invariance of TGD. The interpretation of GRT space-time is as effective space-time obtained by replacing many-sheeted space-time with Minkowski space with effective metric determined as a sum of Minkowski metric and sum over the deviations of the induced metrics of the space-time sheets from Minkowski metric. Poincare invariance strongly suggests classical EP for the GRT limit in long length scales at least. One can also consider other kinds of limits such as the analog of GRT limit for Euclidian space-time regions assignable to elementary particles. In this case deformations of CP_2 metric define a natural starting point and CP_2 indeed defines a gravitational instanton with a very large cosmological constant in Einstein-Maxwell theory. Also gauge potentials of the standard model correspond classically to superpositions of induced gauge potentials over space-time sheets.

Topological Field Quantization

Topological field quantization distinguishes between TGD based and more standard - say Maxwellian - notion of field. In Maxwell's fields created by separate systems superpose and one cannot tell which part of field comes from which system except theoretically. In TGD these fields correspond to different space-time sheets and only their effects on test particle superpose. Hence physical systems have well-defined field identifies - field bodies - in particular magnetic bodies.

The notion of magnetic body carrying dark matter with non-standard large value of Planck constant has become central concept in TGD inspired theory of consciousness and living matter, and by starting from various anomalies of biology one ends up to a rather detailed view about the role of magnetic body as intentional agent receiving sensory input from the biological body and controlling it using EEG and its various scaled up variants as a communication tool. Among other thins this leads to models for cell membrane, nerve pulse, and EEG.

1.1.4 Quantum TGD as Spinor Geometry of World of Classical Worlds

A turning point in the attempts to formulate a mathematical theory was reached after seven years from the birth of TGD. The great insight was "Do not quantize". The basic ingredients to the new approach have served as the basic philosophy for the attempt to construct Quantum TGD since then and have been the following ones.

World of Classical Worlds

The notion of WCW reduces the interacting quantum theory to a theory of free WCW spinor fields.

1. Quantum theory for extended particles is free(!), classical(!) field theory for a generalized Schrödinger amplitude identified as WCW spinor in the configuration space CH ("world of classical worlds", WCW) consisting of all possible 3-surfaces in H. "All possible" means that surfaces with arbitrary many disjoint components and with arbitrary internal topology and also singular surfaces topologically intermediate between two different manifold topologies are included.

2. 4-D general coordinate invariance forces holography and replaces the ill-defined path integral over all space-time surfaces with a discrete sum over 4-D analogs of Bohr orbits for particles identified as 3-surfaces. Holography means that basic objects are these analogs of Bohr orbits. Since there is no quantization at the level of WCW, one has an analog of wave mechanics with point-like particles replaced with 4-D Bohr orbits.

3. One must geometrize WCW as the space of Bohr orbits. In an infinite-dimensional situation the existence of geometry requires maximal symmetries already in the case of loop spaces. Physics is unique from its mathematical existence.

   WCW is endowed with   metric and spinor structure so that one can define various metric related differential operators, say Dirac operators, appearing in the field equations of the theory [1]

Identification of Kähler function

The evolution of these basic ideas has been rather slow but has gradually led to a rather beautiful vision. One of the key problems has been the definition of Kähler function. Kähler function is Kähler action for a preferred extremal assignable to a given 3-surface but what this preferred extremal is? The obvious first guess was as absolute minimum of Kähler action but could not be proven to be right or wrong. One big step in the progress was boosted by the idea that TGD should reduce to almost topological QFT in which braids would replace 3-surfaces in finite measurement resolution, which could be inherent property of the theory itself and imply discretization at partonic 2-surfaces with discrete points carrying fermion number.

It took long time to realize that there is no discretization in 4-D sense - this would lead to difficulties with basic symmetries. Rather, the discretization occurs for the parameters characterizing co-dimension 2 objects representing the information about space-time surface so that they belong to some algebraic extension of rationals. These 2-surfaces - string world sheets and partonic 2-surfaces - are genuine physical objects rather than a computational approximation. Physics itself approximates itself, one might say! This is of course nothing but strong form of holography.

1. TGD as almost topological QFT vision suggests that Kähler action for preferred extremals reduces to Chern-Simons term assigned with space-like 3-surfaces at the ends of space-time (recall the notion of causal diamond (CD)) and with the light-like 3-surfaces at which the signature of the induced metric changes from Minkowskian to Euclidian. Minkowskian and Euclidian regions would give at wormhole throats the same contribution apart from coefficients and in Minkowskian regions the $\sqrt{g_4}$ factorc coming from metric would be imaginary so that one would obtain sum of real term identifiable as Kähler function and imaginary term identifiable as the ordinary Minkowskian action giving rise to interference effects and stationary phase approximation central in both classical and quantum field theory.

   Imaginary contribution - the presence of which I realized only after 33 years of TGD - could also have topological interpretation as a Morse function. On physical side the emergence of Euclidian space-time regions is something completely new and leads to a dramatic modification of the ideas about black hole interior.

2. The way to achieve the reduction to Chern-Simons terms is simple. The vanishing of Coulomb contribution to Kähler action is required and is true for all known extremals if one makes a general ansatz about the form of classical conserved currents. The so called weak form of electric-magnetic duality defines a boundary condition reducing the resulting 3-D terms to Chern-Simons terms. In this way almost topological QFT results. But only "almost" since the Lagrange multiplier term forcing electric-magnetic duality implies that Chern-Simons action for preferred extremals depends on metric.

WCW spinor fields

Classical WCW spinor fields are analogous to Schrödinger amplitudes and the construction of WCW Kähler geometry reduces to the second quantization of free spinor fields of H.

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[1] There are four kinds of Dirac operators in TGD. The geometrization of quantum theory requires Kähler metric definable either in terms of Kähler function identified as a the bosonic action for Euclidian space-time regions or as anti-commutators for WCW gamma matrices identified as conformal Noether super-charges associated with the second quantized modified Dirac action consisting of string world sheet term and possibly also modified Dirac action in Minkowskian space-time regions. These two possible definitions reflect a duality analogous to AdS/CFT duality.

1. The WCW metric is given by anticommutators of WCW gamma matrices which also have interpretation as supercharges assignable to the generators of WCW isometries and allowing expression as non-conserved Noether charges. Holography implies zero energy ontology (ZEO) meaning that zero energy states are superpositions of Bohr orbits connecting boundaries of causal diamond (CD). CDs form a fractal hierarchy and their space forming the spine of WCW is finite-dimensional and can be geometrized. The alternative interpretation is as a superposition of pairs of ordinary 3-D fermionic states assignable to the ends of the space-time surfaces.

2. There are several Dirac operators. WCW Dirac operator D_{WCW} appears in Super-symplectic gauge conditions analogous to Super Virasoro conditions. The algebraic variant of the H Dirac operator D_H appears in fermionic correlation functions: this is due to the fact that free fermions appearing as building bricks of WCW gamma matrices are modes of D_H. The modes of $_DH$ define the ground states of super-symplectic representations. There is also the modified Dirac operator D_{X^4} acting on the induced spinors at space-time surfaces and it is dictated by symmetry one the action fixing the space-time surfaces as Bohr orbits is fixed. D_H is needed since it determines the expressions of WCW gamma matrices as Noether charges assignable to 3-surfaces at the ends of WCW.

The role of modified Dirac action

1. By quantum classical correspondence, the construction of WCW spinor structure in sectors assignable to CDs reduces to the second quantization of the induced spinor fields of H. The basic action is so called modified Dirac action in which gamma matrices are replaced with the modified) gamma matrices defined as contractions of the canonical momentum currents of the bosonic action defining the space-time surfaces with the embedding space gamma matrices. In this way one achieves super-conformal symmetry and conservation of fermionic currents among other things and a consistent Dirac equation.

   Modified Dirac action is needed to define WCW gamma matrices as super charges assignable to WCW isometry generators identified as generators of symplectic transformations and by holography are needed only at the 3-surface at the boundaries of WCW. It is important to notice that the modified Dirac equation does not determine propagators since induced spinor fields are obtained from free second quantized spinor fields of H. This means enormous simplification and makes the theory calculable.

2. An important interpretational problem relates to the notion of the induced spinor connection. The presence of classical W boson fields is in conflict with the classical conservation of em charge since the coupling to classical W fields changes em charge.

   One way out of the problem is the fact that the quantum averages of weak and gluon fields vanish unlike the quantum average of the em field. This leads to a rather precise understanding of electroweak symmetry breaking as being due the fact that color symmetries rotate space-time surfaces and also affect the induced weak fields.

   One can also consider a stronger condition. If one requires that the spinor modes have well-defined em charge, one must assume that the modes in the generic situation are localized at 2-D surfaces - string world sheets or perhaps also partonic 2-surfaces - at which classical W boson fields vanish. Covariantly constant right handed neutrinos generating super-symmetries forms an exception. The vanishing of the Z^0 field is possible for Kähler-Dirac action and should hold true at least above weak length scales. This implies that the string model in 4-D space-time becomes part of TGD. Without these conditions classical weak fields can vanish above weak scale only for the GRT limit of TGD for which gauge potentials are sums over those for space-time sheets.

   The localization would simplify the mathematics enormously and one can solve exactly the Kähler-Dirac equation for the modes of the induced spinor field just like in super string models.

   At the light-like 3-surfaces the signature of the induced metric changes from Euclidian to Minkowskian so that $\sqrt{g_4}$ vanishes. One can pose the condition that the algebraic analog of

the massless Dirac equation is satisfied by the modes of the modified-Dirac action assignable to the Chern-Simons-Kähler action.

1.1.5 Construction of scattering amplitudes

Reduction of particle reactions to space-time topology

Particle reactions are identified as topology changes [A18, A20, A22]. For instance, the decay of a 3-surface to two 3-surfaces corresponds to the decay $A \to B + C$. Classically this corresponds to a path of WCW leading from 1-particle sector to 2-particle sector. At quantum level this corresponds to the dispersion of the generalized Schrödinger amplitude localized to 1-particle sector to two-particle sector. All coupling constants should result as predictions of the theory since no nonlinearities are introduced.

During years this naïve and very rough vision has of course developed a lot and is not anymore quite equivalent with the original insight. In particular, the space-time correlates of Feynman graphs have emerged from theory as Euclidian space-time regions and the strong form of General Coordinate Invariance has led to a rather detailed and in many respects un-expected visions. This picture forces to give up the idea about smooth space-time surfaces and replace space-time surface with a generalization of Feynman diagram in which vertices represent the failure of manifold property. I have also introduced the word "world of classical worlds" (WCW) instead of rather formal "configuration space". I hope that "WCW" does not induce despair in the reader having tendency to think about the technicalities involved!

Construction of the counterparts of S-matrices

What does one mean with the counterpart of S-matrix in the TGD framework has been a long standing problem. The development of ZEO based quantum measurement theory has led to a rough overall view of the situation.

1. There are two kinds of state function reductions (SFRs). "Small" SFRs (SSFRs) following the TGD counterpart of a unitary time evolution defines a sequence of SFRs, which is analogous to a sequence of repeated quantum measurements associated with the Zeno effect. In wave mechanics nothing happens in these measurements. In quantum optics these measurements correspond to weak measurements. In TGD SSFR affects the zero energy state but leaves the 3-D state at the passive boundary of CD unaffected.

2. In TGD framework each SSFR is preceded by a counterpart of a unitary time evolution, which means dispersion in the space of CDs and unitary time evolution in fermionic degrees of freedom such that the passive boundary of CDs and 3-D states at it are unaffected but a superposition of CDs with varying active boundaries in the space of CDs is formed. In SSFR a localization in the space of CDs occurs such that the active is fixed. In a statistical sense the size of the CD increases and the increasing distance between the tips of the CD gives rise to the arrow of geometric time.

3. Also "big" SFRS (BSFRs) can occur and they correspond to ordinary SFRs. In BSFR the roles of the active and passive boundary are changed and this means that the arrow of time is changed. Big SFR occurs when the SSFR corresponds to a quantum measurement, which does not commute with the operators, which define the states at the passive boundary of CD as their eigenstates. This means a radical deviation from standard quantum measurement theory and has predictions in all scales.

4. One can assign the counterpart of S-matrix to the unitary time evolution between two subsequent SSFRs and also to the counterpart of S-matrix associated with BSFR. At least in the latter case the dimension of the state space can increase since at least BSFRs lead to the increase of the dimension of algebraic extension of rationals assignable to the space-time surface by $M^8 - H$ duality. Unitarity is therefore replaced with isometry.

5. I have also considered the possibility that unitary S-matrix could be replaced in the fermionic degrees of freedom with Kähler metric of the state space satisfying analogs of unitarity conditions but it seems that this is un-necessary and also too outlandish an idea.

The notion of M-matrix

1. The most ambitious dream is that zero energy states correspond to a complete solution basis for the Dirac operators associated with WCWs associated with the spaces of CDs with fixed passive boundary: this would define an S-matrix assignable to SFR. Also the analog of S-matrix for the localizations of the states to the active boundary assignable to the BSFR changing the state at the passive boundary of CD is needed.

2. If one allows entanglement between positive and energy parts of the zero energy state but assumes that the states at the passive boundary are fixed, one must introduce the counterpart of the density matrix, or rather its square root. This classical free field theory would dictate what I have called M-matrices defined between positive and negative energy parts of zero energy states which form orthonormal rows of what I call U-matrix as a matrix defined between zero energy states. A biven M-matrix in turn would decompose to a product of a hermitian square root of density matrix and unitary S-matrix.

3. M-matrix would define time-like entanglement coefficients between positive and negative energy parts of zero energy states (all net quantum numbers vanish for them) and can be regarded as a hermitian square root of density matrix multiplied by a unitary S-matrix. Quantum theory would be in a well-defined sense a square root of thermodynamics. The orthogonality and hermiticity of the M-matrices commuting with S-matrix means that they span infinite-dimensional Lie algebras acting as symmetries of the S-matrix. Therefore quantum TGD would reduce to group theory in a well-defined sense.

4. In fact the Lie algebra of Hermitian M-matrices extends to Kac-Moody type algebra obtained by multiplying hermitian square roots of density matrices with powers of the S-matrix. Also the analog of Yangian algebra involving only non-negative powers of S-matrix is possible and would correspond to a hierarchy of CDs with the temporal distances between tips coming as integer multiples of the CP_2 time.

   The M-matrices associated with CDs are obtained by a discrete scaling from the minimal CD and characterized by integer n are naturally proportional to a representation matrix of scaling: $S(n) = S^n$, where S is unitary S-matrix associated with the minimal CD [K75]. This conforms with the idea about unitary time evolution as exponent of Hamiltonian discretized to integer power of S and represented as scaling with respect to the logarithm of the proper time distance between the tips of CD.

5. I have also considered the notion of U-matrix. U-matrix elements between M-matrices for various CDs are proportional to the inner products $Tr[S^{-n_1} \circ H^i H^j \circ S^{n_2} \lambda]$, where λ represents unitarily the discrete Lorentz boost relating the moduli of the active boundary of CD and H^i form an orthonormal basis of Hermitian square roots of density matrices. $\circ$ tells that S acts at the active boundary of CD only. I have proposed a general representation for the U-matrix, reducing its construction to that of the S-matrix.

1.1.6   TGD as a generalized number theory

Quantum T(opological)D(ynamics) as a classical spinor geometry for infinite-dimensional configuration space ("world of classical worlds", WCW), p-adic numbers and quantum TGD, and TGD inspired theory of consciousness, have been for last ten years the basic three strongly interacting threads in the tapestry of quantum TGD. The fourth thread deserves the name "TGD as a generalized number theory". It involves three separate threads: the fusion of real and various p-adic physics to a single coherent whole by requiring number theoretic universality discussed already, the formulation of quantum TGD in terms of complexified counterparts of classical number fields, and the notion of infinite prime. Note that one can identify subrings such as hyper-quaternions and hyper-octonions as sub-spaces of complexified classical number fields with Minkowskian signature of the metric defined by the complexified inner product.

The Threads in the Development of Quantum TGD

The development of TGD has involved several strongly interacting threads: physics as infinite-dimensional geometry; TGD as a generalized number theory, the hierarchy of Planck constants interpreted in terms of dark matter hierarchy, and TGD inspired theory of consciousness. In the following these threads are briefly described.

1. Quantum T(opological) G(eometro)D(ynamics) as a classical spinor geometry for infinite-dimensional WCW, p-adic numbers and quantum TGD, and TGD inspired theory of consciousness and of quantum biology have been for last decade of the second millenium the basic three strongly interacting threads in the tapestry of quantum TGD.

2. The discussions with Tony Smith initiated a fourth thread which deserves the name "TGD as a generalized number theory". The basic observation was that classical number fields might allow a deeper formulation of quantum TGD. The work with Riemann hypothesis made time ripe for realization that the notion of infinite primes could provide, not only a reformulation, but a deep generalization of quantum TGD. This led to a thorough and rather fruitful revision of the basic views about what the final form and physical content of quantum TGD might be. Together with the vision about the fusion of p-adic and real physics to a larger coherent structure these sub-threads fused to the "physics as generalized number theory" thread.

3. A further thread emerged from the realization that by quantum classical correspondence TGD predicts an infinite hierarchy of macroscopic quantum systems with increasing sizes, that it is not at all clear whether standard quantum mechanics can accommodate this hierarchy, and that a dynamical quantized Planck constant might be necessary and strongly suggested by the failure of strict determinism for the fundamental variational principle. The identification of hierarchy of Planck constants labelling phases of dark matter would be natural. This also led to a solution of a long standing puzzle: what is the proper interpretation of the predicted fractal hierarchy of long ranged classical electro-weak and color gauge fields. Quantum classical correspondences allows only single answer: there is infinite hierarchy of p-adically scaled up variants of standard model physics and for each of them also dark hierarchy. Thus TGD Universe would be fractal in very abstract and deep sense.

The chronology based identification of the threads is quite natural but not logical and it is much more logical to see p-adic physics, the ideas related to classical number fields, and infinite primes as sub-threads of a thread which might be called "physics as a generalized number theory". In the following I adopt this view. This reduces the number of threads to three corresponding to geometric, number theoretic and topological views of physics.

TGD forces the generalization of physics to a quantum theory of consciousness, and TGD as a generalized number theory vision leads naturally to the emergence of p-adic physics as physics of cognitive representations.

Number theoretic vision very briefly

Number theoretic vision about quantum TGD involves notions like adelic physics, $M^8 - H$ duality and number theoretic universality. A short review of the basic ideas that have developed during years is in order.

1. The physical interpretation of M^8 is as an analog of momentum space and $M^8 - H$ duality is analogous to momentum-position duality of ordinary wave mechanics.

2. Adelic physics means that all classical number fields, all p-adic number fields and their extensions induced by extensions of rationals and defining adeles, and also finite number fields are basic mathematical building bricks of physics.

   The complexification of M^8, identified as complexified octonions, would provide a realization of this picture and $M^8 - H$ duality would map the algebraic physics in M^8 to the ordinary physics in $M^4 \times CP_2$ described in terms of partial differential equations.

3. Negentropy Maximization Principle (NMP) states that the conscious information assignable with cognition representable measured in terms of p-adic negentropy increases in statistical sense.

   NMP is mathematically completely analogous to the second law of thermodynamics and number theoretic evolution as an unavoidable statistical increase of the dimension of the algebraic extension of rationals characterizing a given space-time region implies it. There is no paradox involved: the p-adic negentropy measures the conscious information assignable to the entanglement of two systems regarded as a conscious entity whereas ordinary entropy measures the lack of information about the quantums state of either entangled system.

4. Number theoretical universality requires that space-time surfaces or at least their $M^8 - H$ duals in M_c^8 are defined for both reals and various p-adic number fields. This is true if they are defined by polynomials with integer coefficients as surfaces in M^8 obeying number theoretic holography realized as associativity of the normal space of 4-D surface using as holographic data 3-surfaces at mass shells identified in terms of roots of a polynomial. A physically motivated additional condition is that the coefficients of the polynomials are smaller than their degrees.

5. Galois confinement is a key piece of the number theoretic vision. It states that the momenta of physical states are algebraic integers in the extensions of rationals assignable to the space-time region considered. These numbers are in general complex and are not consistent with particle in box quantization. The proposal is that physical states satisfy Galois confinement being thus Galois singlets and having therefore total momenta, whose components are ordinary integers, when momentum unit defined by the scale of causal diamond (CD) is used.

6. The notion of p-adic prime was introduced in p-adic mass calculations that started the developments around 1995. p-Adic length scale hypothesis states that p-adic primes near powers of 2 have a special physical role (as possibly also the powers of other small primes such as $p = 3$).

   The proposal is that p-adic primes correspond to ramified primes assignable to the extension and identified as divisors of the polynomial defined by the products of the root differences for the roots of the polynomial defining space-time space and having interpretation as values of, in general complex, virtual mass squared.

p-Adic TGD and fusion of real and p-adic physics to single coherent whole

The p-adic thread emerged for roughly ten years ago as a dim hunch that p-adic numbers might be important for TGD. Experimentation with p-adic numbers led to the notion of canonical identification mapping reals to p-adics and vice versa. The breakthrough came with the successful p-adic mass calculations using p-adic thermodynamics for Super-Virasoro representations with the super-Kac-Moody algebra associated with a Lie-group containing standard model gauge group. Although the details of the calculations have varied from year to year, it was clear that p-adic physics reduces not only the ratio of proton and Planck mass, the great mystery number of physics, but all elementary particle mass scales, to number theory if one assumes that primes near prime powers of two are in a physically favored position. Why this is the case, became one of the key puzzles and led to a number of arguments with a common gist: evolution is present already at the elementary particle level and the primes allowed by the p-adic length scale hypothesis are the fittest ones.

It became very soon clear that p-adic topology is not something emerging in Planck length scale as often believed, but that there is an infinite hierarchy of p-adic physics characterized by p-adic length scales varying to even cosmological length scales. The idea about the connection of p-adics with cognition motivated already the first attempts to understand the role of the p-adics and inspired "Universe as Computer" vision but time was not ripe to develop this idea to anything concrete (p-adic numbers are however in a central role in TGD inspired theory of consciousness). It became however obvious that the p-adic length scale hierarchy somehow corresponds to a hierarchy of intelligences and that p-adic prime serves as a kind of intelligence quotient. Ironically, the almost obvious idea about p-adic regions as cognitive regions of space-time providing cognitive representations for real regions had to wait for almost a decade for the access into my consciousness.

In string model context one tries to reduces the physics to Planck scale. The price is the inability to say anything about physics in long length scales. In TGD p-adic physics takes care of this shortcoming by predicting the physics also in long length scales.

There were many interpretational and technical questions crying for a definite answer.

1. What is the relationship of p-adic non-determinism to the classical non-determinism of the basic field equations of TGD? Are the p-adic space-time region genuinely p-adic or does p-adic topology only serve as an effective topology? If p-adic physics is direct image of real physics, how the mapping relating them is constructed so that it respects various symmetries? Is the basic physics p-adic or real (also real TGD seems to be free of divergences) or both? If it is both, how should one glue the physics in different number field together to get *the* Physics? Should one perform p-adicization also at the level of the WCW? Certainly the p-adicization at the level of super-conformal representation is necessary for the p-adic mass calculations.

2. Perhaps the most basic and most irritating technical problem was how to precisely define p-adic definite integral which is a crucial element of any variational principle based formulation of the field equations. Here the frustration was not due to the lack of solution but due to the too large number of solutions to the problem, a clear symptom for the sad fact that clever inventions rather than real discoveries might be in question. Quite recently I however learned that the problem of making sense about p-adic integration has been for decades central problem in the frontier of mathematics and a lot of profound work has been done along same intuitive lines as I have proceeded in TGD framework. The basic idea is certainly the notion of algebraic continuation from the world of rationals belonging to the intersection of real world and various p-adic worlds.

Despite various uncertainties, the number of the applications of the poorly defined p-adic physics has grown steadily and the applications turned out to be relatively stable so that it was clear that the solution to these problems must exist. It became only gradually clear that the solution of the problems might require going down to a deeper level than that represented by reals and p-adics.

The key challenge is to fuse various p-adic physics and real physics to single larger structure. This has inspired a proposal for a generalization of the notion of number field by fusing real numbers and various p-adic number fields and their extensions along rationals and possible common algebraic numbers. This leads to a generalization of the notions of embedding space and space-time concept and one can speak about real and p-adic space-time sheets. One can talk about adelic space-time, embedding space, and WCW.

The corresponds of real 4-surfaces with the p-adic ones is induced by number theoretical discretization using points of 4-surfaces $Y^4 \subset M_c^8$ identifiable as 8-momenta, whose components are assumed to be algebraic integers in an extension of rationals defined by the extension of rationals associated with a polynomial P with integer coefficients smaller than the degree of P. These points define a cognitive representation, which is universal in the sense that it exists also in the algebraic extensions of p-adic numbers. The points of the cognitive representations associated with the mass shells with mass squared values identified as roots of P are enough since $M^8 - H$ duality can be used at both M^8 and H sides and also in the p-adic context. The mass shells are special in that they allow for Minkowski coordinates very large cognitive representations unlike the interiors of the 4-surfaces determined by holography by using the data defined by the 3-surfaces at the mass shells. The higher the dimension of the algebraic extension associated with P, the better the accuracy of the cognitive representation.

Adelization providing number theoretical universality reduces to algebraic continuation for the amplitudes from this intersection of reality and various p-adicities - analogous to a back of a book - to various number fields. There are no problems with symmetries but canonical identification is needed: various group invariant of the amplitude are mapped by canonical identification to various p-adic number fields. This is nothing but a generalization of the mapping of the p-adic mass squared to its real counterpart in p-adic mass calculations.

This leads to surprisingly detailed predictions and far reaching conjectures. For instance, the number theoretic generalization of entropy concept allows negentropic entanglement central for the applications to living matter (see **Fig.** `http://tgdtheory.fi/appfigures/cat.jpg` or **Fig. ??** in the appendix of this book). One can also understand how preferred p-adic primes could

emerge as so called ramified primes of algebraic extension of rationals in question and characterizing string world sheets and partonic 2-surfaces. Preferred p-adic primes would be ramified primes for extensions for which the number of p-adic continuations of two-surfaces to space-time surfaces (imaginations) allowing also real continuation (realization of imagination) would be especially large. These ramifications would be winners in the fight for number theoretical survival. Also a generalization of p-adic length scale hypothesis emerges from NMP [K70].

The characteristic non-determinism of the p-adic differential equations suggests strongly that p-adic regions correspond to "mind stuff", the regions of space-time where cognitive representations reside. This interpretation implies that p-adic physics is physics of cognition. Since Nature is probably a brilliant simulator of Nature, the natural idea is to study the p-adic physics of the cognitive representations to derive information about the real physics. This view encouraged by TGD inspired theory of consciousness clarifies difficult interpretational issues and provides a clear interpretation for the predictions of p-adic physics.

Infinite primes

The discovery of the hierarchy of infinite primes and their correspondence with a hierarchy defined by a repeatedly second quantized arithmetic quantum field theory gave a further boost for the speculations about TGD as a generalized number theory.

After the realization that infinite primes can be mapped to polynomials possibly representable as surfaces geometrically, it was clear how TGD might be formulated as a generalized number theory with infinite primes forming the bridge between classical and quantum such that real numbers, p-adic numbers, and various generalizations of p-adics emerge dynamically from algebraic physics as various completions of the algebraic extensions of complexified quaternions and octonions. Complete algebraic, topological and dimensional democracy would characterize the theory.

The infinite primes at the first level of hierarchy, which represent analogs of bound states, can be mapped to irreducible polynomials, which in turn characterize the algebraic extensions of rationals defining a hierarchy of algebraic physics continuable to real and p-adic number fields. The products of infinite primes in turn define more general algebraic extensions of rationals. The interesting question concerns the physical interpretation of the higher levels in the hierarchy of infinite primes and integers mappable to polynomials of $n > 1$ variables.

1.1.7   An explicit formula for $M^8 - H$ duality

$M^8 - H$ duality is a generalization of momentum-position duality relating the number theoretic and geometric views of physics in TGD and, despite that it still involves poorly understood aspects, it has become a fundamental building block of TGD. One has 4-D surfaces $Y^4 \subset M_c^8$, where M_c^8 is complexified M^8 having interpretation as an analog of complex momentum space and 4-D spacetime surfaces $X^4 \subset H = M^4 \times CP_2$. M_c^8, equivalently E_c^8, can be regarded as complexified octonions. M_c^8 has a subspace M_c^4 containing M^4.

Comment: One should be very cautious with the meaning of "complex". Complexified octonions involve a complex imaginary unit i commuting with the octonionic imaginary units I_k. i is assumed to also appear as an imaginary unit also in complex algebraic numbers defined by the roots of polynomials P defining holographic data in M_c^8.

In the following $M^8 - H$ duality and its twistor lift are discussed and an explicit formula for the dualities are deduced. Also possible variants of the duality are discussed.

Holography in H

$X^4 \subset H$ satisfies holography and is analogous to the Bohr orbit of a particle identified as a 3-surface. The proposal is that holography reduces to a 4-D generalization of holomorphy so that X^4 is a simultaneous zero of two functions of complex CP_2 coordinates and of what I have called Hamilton-Jacobi coordinates of M^4 with a generalized Kähler structure.

The simplest choice of the Hamilton-Jacobi coordinates is defined by the decomposition $M^4 = M^2 \times E^2$, where M^2 is endowed with hypercomplex structure defined by light-like coordinates (u, v), which are analogous to z and $\overline{z}$. Any analytic map $u \to f(u)$ defines a new set

of light-like coordinates and corresponds to a solution of the massless d'Alembert equation in M^2. E^2 has some complex coordinates with imaginary unit defined by i.

The conjecture is that also more general Hamilton-Jacobi structures for which the tangent space decomposition is local are possible. Therefore one would have $M^4 = M^2(x) \times E^2(x)$. These would correspond to non-equivalent complex and Kähler structures of M^4 analogous to those possessed by 2-D Riemann surfaces and parametrized by moduli space.

Number theoretic holography in M_c^8

$Y^4 \subset M_c^8$ satisfies number theoretic holography defining dynamics, which should reduce to associativity in some sense. The Euclidian complexified normal space $N^4(y)$ at a given point y of Y^4 is required to be associative, i.e. quaternionic. Besides this, $N^4(i)$ contains a preferred complex Euclidian 2-D subspace $Y^2(y)$. Also the spaces $Y^2(x)$ define an integrable distribution. I have assumed that $Y^2(x)$ can depend on the point y of Y^4.

These assumptions imply that the normal space $N(y)$ of Y^4 can be parameterized by a point of $CP_2 = SU(3)/U(2)$. This distribution is always integrable unlike quaternionic tangent space distributions. $M^8 - H$ duality assigns to the normal space $N(y)$ a point of CP_2. M_c^4 point y is mapped to a point $x \in M^4 \subset M^4 \times CP_2$ defined by the real part of its inversion (conformal transformation): this formula involves effective Planck constant for dimensional reasons.

The 3-D holographic data, which partially fixes 4-surfaces Y^4 is partially determined by a polynomial P with real integer coefficients smaller than the degree of P. The roots define mass squared values which are in general complex algebraic numbers and define complex analogs of mass shells in $M_c^4 \subset M_c^8$, which are analogs of hyperbolic spaces H^3. The 3-surfaces at these mass shells define 3-D holographic data continued to a surface Y^4 by requiring that the normal space of Y^4 is associative, i.e. quaternionic. These 3-surfaces are not completely fixed but an interesting conjecture is that they correspond to fundamental domains of tessellations of H^3.

What does the complexity of the mass shells mean? The simplest interpretation is that the space-like M^4 coordinates (3-momentum components) are real whereas the time-like coordinate (energy) is complex and determined by the mass shell condition. One would have $Re^2(E) - Im(E)^2 - p^2 = Re(m^2)$ and $2Re(E)Im(E) = Im(m^2)$. The condition for the real parts gives H^3 when $\sqrt{Re^2(E) - Im(E)^2}$ is taken as a time coordinate. The second condition allows to solve $Im(E)$ in terms of $Re(E)$ so that the first condition reduces to an equation of mass shell when $\sqrt{(Re(E)^2 - Im(E)^2)}$, expressed in terms of $Re(E)$, is taken as new energy coordinate $E_{eff} = \sqrt{(Re(E)^2 - Im(E)^2)}$. Is this deformation of H^3 in imaginary time direction equivalent with a region of the hyperbolic 3-space H^3?

One can look at the formula in more detail. Mass shell condition gives $Re^2(E) - Im(E)^2 - p^2 = Re(m^2)$ and $2Re(E)Im(E) = Im(m^2)$. The condition for the real parts gives H^3, when $\sqrt{Re^2(E) - Im(E)^2}$ is taken as an effective energy. The second condition allows to solve $Im(E)$ in terms of $Re(E)$ so that the first condition reduces to a dispersion relation for $Re(E)^2$.

$$Re(E)^2 = \frac{1}{2}(Re(m^2) - Im(m^2) + p^2)(1 \pm \sqrt{1 + \frac{2Im(m^2)^2}{(Re(m^2) - Im(m^2) + p^2)^2}}) \ . \qquad (1.1.1)$$

Only the positive root gives a non-tachyonic result for $Re(m^2) - Im(m^2) > 0$. For real roots with $Im(m^2) = 0$ and at the high momentum limit the formula coincides with the standard formula. For $Re(m^2) = Im(m^2)$ one obtains $Re(E)^2 \to Im(m^2)/\sqrt{2}$ at the low momentum limit $p^2 \to 0$. Energy does not depend on momentum at all: the situation resembles that for plasma waves.

Can one find an explicit formula for $M^8 - H$ duality?

The dream is an explicit formula for the $M^8 - H$ duality mapping $Y^4 \subset M_c^8$ to $X^4 \subset H$. This formula should be consistent with the assumption that the generalized holomorphy holds true for X^4.

The following proposal is a more detailed variant of the earlier proposal for which Y^4 is determined by a map g of $M_c^4 \to SU(3)_c \subset G_{2,c}$, where $G_{2,c}$ is the complexified automorphism group of octonions and $SU(3)_c$ is interpreted as a complexified color group.

This map defines a trivial $SU(3)_c$ gauge field. The real part of g however defines a non-trivial real color gauge field by the non-linearity of the non-abelian gauge field with respect to the gauge potential. The quadratic terms involving the imaginary part of the gauge potential give an additional condition to the real part in the complex situation and cancel it. If only the real part of g contributes, this contribution would be absent and the gauge field is non-vanishing.

How could the automorphism $g(x) \subset SU(3) \subset G_2$ give rise to $M^8 - H$ duality?

1. The interpretation is that $g(y)$ at given point y of Y^4 relates the normal space at y to a fixed quaternionic/associative normal space at point y_0, which corresponds is fixed by some subgroup $U(2)_0 \subset SU(3)$. The automorphism property of g guarantees that the normal space is quaternionic/associative at y. This simplifies the construction dramatically.

2. The quaternionic normal sub-space (which has Euclidian signature) contains a complex sub-space which corresponds to a point of sphere $S^2 = SO(3)/O(2)$, where $SO(3)$ is the quaternionic automorphism group. The interpretation could be in terms of a selection of spin quantization axes. The local choice of the preferred complex plane would not be unique and is analogous to the possibility of having non-trivial Hamilton Jacobi structures in M^4 characterized by the choice of $M^2(x)$ and equivalently its normal subspace $E^2(x)$.

   These two structures are independent apart from dependencies forced by the number theoretic dynamics. Hamilton-Jacobi structure means a selection of the quantization axis of spin and energy by fixing a distribution of light-like tangent vectors of M^4 and the choice of the quaternionic normal sub-space fixes a choice of preferred quaternionic imaginary unit defining a quantization axis of the weak isospin.

3. The real part $Re(g(y))$ defines a point of $SU(3)$ and the bundle projection $SU(3) \rightarrow CP_2$ in turn defines a point of $CP_2 = SU(3)/U(2)$. Hence one can assign to g a point of CP_2 as $M^8 - H$ duality requires and deduce an explicit formula for the point. This means a realization of the dream.

4. The construction requires a fixing of a quaternionic normal space N_0 at y_0 containing a preferred complex subspace at a single point of Y^4 plus a selection of the function g. If M^4 coordinates are possible for Y^4, the first guess is that g as a function of complexified M^4 coordinates obeys generalized holomorphy with respect to complexified M^4 coordinates in the same sense and in the case of X^4. This might guarantee that the $M^8 - H$ image of Y^4 satisfies the generalized holomorphy.

5. Also space-time surfaces X^4 with M^4 projection having a dimension smaller than 4 are allowed. I have proposed that they might correspond to singular cases for the above formula: a kind of blow-up would be involved.   One can also consider a more general definition of Y^4 allowing it to have a M^4 projection with dimension smaller than 4 (say cosmic strings). Could one have implicit equations for the surface Y^4 in terms of the complex coordinates of $SU(3)_c$ and M^4? Could this give for instance cosmic strings with a 2-D M^4 projection and CP_2 type extremals with 4-D CP_2 projection and 1-D light-like M^4 projection?

What could the number theoretic holography mean physically?

What could be physical meaning of the number theoretic holography? The condition that has been assumed is that the CP_2 coordinates at the mass shells of $M_c^4 \subset M_c^8$ mapped to mass shells H^3 of $M^4 \subset M^4 \times CP_2$ are constant at the H^3. This is true if the $g(y)$ defines the same CP_2 point for a given component X_i^3 of the 3-surface at a given mass shell. g is therefore fixed apart from a local $U(2)$ transformation leaving the CP_2 point invariant. A stronger condition would be that the CP_2 point is the same for each component of X_i^3 and even at each mass shell but this condition seems to be unnecessarily strong.

Comment: One can o criticize this condition as too strong and one can consider giving up this condition. The motivation for this condition is that the number of algebraic points at the 3-surfaces associated with H^3 explodes since the coordinates associated with normal directions vanish. Kind of cognitive explosion would be in question.

$SU(3)$ corresponds to a subgroup of G_2 and one can wonder what the fixing of this subgroup could mean physically. G_2 is 14-D and the coset space $G_2/SU(3)$ is 6-D and a good guess is that

it is just the 6-D twistor space $SU(3)/U(1) \times U(1)$ of CP_2: at least the isometries are the same. The fixing of the $SU(3)$ subgroup means fixing of a CP_2 twistor. Physically this means the fixing of the quantization axis of color isospin and hypercharge.

Twistor lift of the holography

What is interesting is that by replacing $SU(3)$ with G_2, one obtains an explicit formula form the generalization of $M^8 - H$ duality to that for the twistorial lift of TGD!

One can also consider a twistorial generalization of the above proposal for the number theoretic holography by allowing local G_2 automorphisms interpreted as local choices of the color quantization axis. G_2 elements would be fixed apart from a local $SU(3)$ transformation at the components of 3-surfaces at mass shells. The choice of the color quantization axes for a connected 3-surface at a given mass shell would be the same everywhere. This choice is indeed very natural physically since 3-surface corresponds to a particle.

Is this proposal consistent with the boundary condition of the number theoretical holography mean in the case of 4-surfaces in M_c^8 and $M^4 \times CP_2$?

1. The selection of $SU(3) \subset G_2$ for ordinary $M^8 - H$ duality means that the $G_{2,c}$ gauge field vanishes everywhere and the choice of color quantization axis is the same at all points of the 4-surface. The fixing of the CP_2 point to be constant at H^3 implies that the color gauge field at $H^3 \subset M_c^8$ and its image $H^3 \subset H$ vanish. One would have color confinement at the mass shells H_i^3, where the observations are made. Is this condition too strong?

2. The constancy of the G_2 element at mass shells makes sense physically and means a fixed color quantization axis. The selection of a fixed $SU(3) \subset G_2$ for entire space-time surface is in conflict with the non-constancy of G_2 element unless G_2 element differs at different points of 4-surface only by a multiplication of a local $SU(3)_0$ element, that is local $SU(3)$ transformation. This kind of variation of the G_2 element would mean a fixed color group but varying choice of color quantization axis.

3. Could one consider the possibility that the local $G_{2,c}$ element is free and defines the twistor lift of $M^8 - H$ duality as something more fundamental than the ordinary $M^8 - H$ duality based on $SU(3)_c$. This duality would make sense only at the mass shells so that only the spaces $H^3 \times CP_2$ assignable to mass shells would make sense physically? In the interior CP_2 would be replaced with the twistor space $SU(3)/U(1) \times U(1)$. Color gauge fields would be non-vanishing at the mass shells but outside the mass shells one would have G_2 gauge fields.

   There is also a physical objection against the G_2 option. The 14-D Lie algebra representation of G_2 acts on the imaginary octonions which decompose with respect to the color group to $1 \oplus 3 \oplus \bar{3}$. The automorphism property requires that 1 can be transformed to 3 or $\bar{3}$ to themselves: this requires that the decomposition contains $3 \oplus \bar{3}$. Furthermore, it must be possible to transform 3 and $\bar{3}$ to themselves, which requires the presence of 8. This leaves only the decomposition $8 \oplus 3 \oplus \bar{3}$. G_2 gluons would both color octet and triplets. In the TDG framework the only conceivable interpretation would be in terms of ordinary gluons and leptoquark-like gluons. This does not fit with the basic vision of TGD.

The choice of twistor as a selection of quantization axes should make sense also in the M^4 degrees of freedom. M^4 twistor corresponds to a choice of light-like direction at a given point of M^4. The spatial component of the light-like vector fixes the spin quantization axis. Its choice together with the light-likeness fixes the time direction and therefore the rest system and energy quantization axis. Light-like vector fixes also the choice of M^2 and of E^2 as its orthogonal complement. Therefore the fixing of M^4 twistor as a point of $SU(4)/SU(3) \times U(1)$ corresponds to a choice of the spin quantization axis and the time-like axis defining the rest system in which the energy is measured. This choice would naturally correspond to the Hamilton-Jacobi structure fixing the decompositions $M^2(x) \times E^2(x)$. At a given mass shell the choice of the quantization axis would be constant for a given X_i^3.

1.1.8 Hierarchy of Planck Constants and Dark Matter Hierarchy

By quantum classical correspondence space-time sheets can be identified as quantum coherence regions. Hence the fact that they have all possible size scales more or less unavoidably implies that Planck constant must be quantized and have arbitrarily large values. If one accepts this then also the idea about dark matter as a macroscopic quantum phase characterized by an arbitrarily large value of Planck constant emerges naturally as does also the interpretation for the long ranged classical electro-weak and color fields predicted by TGD. Rather seldom the evolution of ideas follows simple linear logic, and this was the case also now. In any case, this vision represents the fifth, relatively new thread in the evolution of TGD and the ideas involved are still evolving.

Dark Matter as Large $\hbar$ Phases

D. Da Rocha and Laurent Nottale [E2] have proposed that Schrödinger equation with Planck constant $\hbar$ replaced with what might be called gravitational Planck constant $\hbar_{gr} = \frac{GmM}{v_0}$ ($\hbar = c = 1$). v_0 is a velocity parameter having the value $v_0 = 144.7 \pm .7$ km/s giving $v_0/c = 4.6 \times 10^{-4}$. This is rather near to the peak orbital velocity of stars in galactic halos. Also subharmonics and harmonics of v_0 seem to appear. The support for the hypothesis coming from empirical data is impressive.

Nottale and Da Rocha believe that their Schrödinger equation results from a fractal hydrodynamics. Many-sheeted space-time however suggests that astrophysical systems are at some levels of the hierarchy of space-time sheets macroscopic quantum systems. The space-time sheets in question would carry dark matter.

Nottale's hypothesis would predict a gigantic value of h_{gr}. Equivalence Principle and the independence of gravitational Compton length on mass m implies however that one can restrict the values of mass m to masses of microscopic objects so that h_{gr} would be much smaller. Large h_{gr} could provide a solution of the black hole collapse (IR catastrophe) problem encountered at the classical level. The resolution of the problem inspired by TGD inspired theory of living matter is that it is the dark matter at larger space-time sheets which is quantum coherent in the required time scale [K104].

It is natural to assign the values of Planck constants postulated by Nottale to the space-time sheets mediating gravitational interaction and identifiable as magnetic flux tubes (quanta) possibly carrying monopole flux and identifiable as remnants of cosmic string phase of primordial cosmology. The magnetic energy of these flux quanta would correspond to dark energy and magnetic tension would give rise to negative "pressure" forcing accelerate cosmological expansion. This leads to a rather detailed vision about the evolution of stars and galaxies identified as bubbles of ordinary and dark matter inside magnetic flux tubes identifiable as dark energy.

Certain experimental findings suggest the identification $h_{eff} = n \times = h_{gr}$. The large value of h_{gr} can be seen as a way to reduce the string tension of fermionic strings so that gravitational (in fact all!) bound states can be described in terms of strings connecting the partonic 2-surfaces defining particles (analogous to AdS/CFT description). The values $h_{eff}/h = n$ can be interpreted in terms of a hierarchy of breakings of super-conformal symmetry in which the super-conformal generators act as gauge symmetries only for a sub-algebras with conformal weights coming as multiples of n. Macroscopic quantum coherence in astrophysical scales is implied. If also Kähler-Dirac action is present, part of the interior degrees of freedom associated with the Kähler-Dirac part of conformal algebra become physical. A possible is that tfermionic oscillator operators generate super-symmetries and sparticles correspond almost by definition to dark matter with $h_{eff}/h = n > 1$. One implication would be that at least part if not all gravitons would be dark and be observed only through their decays to ordinary high frequency graviton ($E = hf_{high} = h_{eff}f_{low}$) of bunch of n low energy gravitons.

Hierarchy of Planck Constants from the Anomalies of Neuroscience and Biology

The quantal ELF effects of ELF em fields on vertebrate brain have been known since seventies. ELF em fields at frequencies identifiable as cyclotron frequencies in magnetic field whose intensity is about 2/5 times that of Earth for biologically important ions have physiological effects and affect also behavior. What is intriguing that the effects are found only in vertebrates (to my best knowledge). The energies for the photons of ELF em fields are extremely low - about 10^{-10} times

lower than thermal energy at physiological temperatures- so that quantal effects are impossible in the framework of standard quantum theory. The values of Planck constant would be in these situations large but not gigantic.

This inspired the hypothesis that these photons correspond to so large a value of Planck constant that the energy of photons is above the thermal energy. The proposed interpretation was as dark photons and the general hypothesis was that dark matter corresponds to ordinary matter with non-standard value of Planck constant. If only particles with the same value of Planck constant can appear in the same vertex of Feynman diagram, the phases with different value of Planck constant are dark relative to each other. The phase transitions changing Planck constant can however make possible interactions between phases with different Planck constant but these interactions do not manifest themselves in particle physics. Also the interactions mediated by classical fields should be possible. Dark matter would not be so dark as we have used to believe.

The hypothesis $h_{eff} = h_{gr}$ - at least for microscopic particles - implies that cyclotron energies of charged particles do not depend on the mass of the particle and their spectrum is thus universal although corresponding frequencies depend on mass. In bio-applications this spectrum would correspond to the energy spectrum of bio-photons assumed to result from dark photons by h_{eff} reducing phase transition and the energies of bio-photons would be in visible and UV range associated with the excitations of bio-molecules.

Also the anomalies of biology (see for instance [K89, K90, K86]) support the view that dark matter might be a key player in living matter.

Dark Matter as a Source of Long Ranged Weak and Color Fields

Long ranged classical electro-weak and color gauge fields are unavoidable in TGD framework. The smallness of the parity breaking effects in hadronic, nuclear, and atomic length scales does not however seem to allow long ranged electro-weak gauge fields. The problem disappears if long range classical electro-weak gauge fields are identified as space-time correlates for massless gauge fields created by dark matter. Also scaled up variants of ordinary electro-weak particle spectra are possible. The identification explains chiral selection in living matter and unbroken $U(2)_{ew}$ invariance and free color in bio length scales become characteristics of living matter and of bio-chemistry and bio-nuclear physics.

The recent view about the solutions of Kähler- Dirac action assumes that the modes have a well-defined em charge and this implies that localization of the modes to 2-D surfaces (right-handed neutrino is an exception). Classical W boson fields vanish at these surfaces and also classical Z^0 field can vanish. The latter would guarantee the absence of large parity breaking effects above intermediate boson scale scaling like h_{eff}.

1.1.9 Twistors in TGD and connection with Veneziano duality

The twistorialization of TGD has two aspects. The attempt to generalize twistor Grassmannian approach emerged first. It was however followed by the realization that also the twistor lift of TGD at classical space-time level is needed. It turned out that the progress in the understanding of the classical twistor lift has been much faster - probably this is due to my rather limited technical QFT skills.

Twistor lift at space-time level

8-dimensional generalization of ordinary twistors is highly attractive approach to TGD [K114]. The reason is that M^4 and CP_2 are completely exceptional in the sense that they are the only 4-D manifolds allowing twistor space with Kähler structure [A17]. The twistor space of $M^4 \times CP_2$ is Cartesian product of those of M^4 and CP_2. The obvious idea is that space-time surfaces allowing twistor structure if they are orientable are representable as surfaces in H such that the properly induced twistor structure coincides with the twistor structure defined by the induced metric.

In fact, it is enough to generalize the induction of spinor structure to that of twistor structure so that the induced twistor structure need not be identical with the ordinary twistor structure possibly assignable to the space-time surface. The induction procedure reduces to a dimensional reduction of 6-D Kähler action giving rise to 6-D surfaces having bundle structure with twistor

sphere as fiber and space-time as base. The twistor sphere of this bundle is imbedded as sphere in the product of twistor spheres of twistor spaces of M^4 and CP_2.

This condition would define the dynamics, and the original conjecture was that this dynamics is equivalent with the identification of space-time surfaces as preferred extremals of Kähler action. The dynamics of space-time surfaces would be lifted to the dynamics of twistor spaces, which are sphere bundles over space-time surfaces. What is remarkable that the powerful machinery of complex analysis becomes available.

It however turned out that twistor lift of TGD is much more than a mere technical tool. First of all, the dimensionally reduction of 6-D Kähler action contained besides 4-D Kähler action also a volume term having interpretation in terms of cosmological constant. This need not bring anything new, since all known extremals of Kähler action with non-vanishing induced Kähler form are minimal surfaces. There is however a large number of embeddings of twistor sphere of space-time surface to the product of twistor spheres. Cosmological constant has spectrum and depends on length scale, and the proposal is that coupling constant evolution reduces to that for cosmological constant playing the role of cutoff length. That cosmological constant could transform from a mere nuisance to a key element of fundamental physics was something totally new and unexpected.

1. The twistor lift of TGD at space-time level forces to replace 4-D Kähler action with 6-D dimensionally reduced Kähler action for 6-D surface in the 12-D Cartesian product of 6-D twistor spaces of M^4 and CP_2. The 6-D surface has bundle structure with twistor sphere as fiber and space-time surface as base.

   Twistor structure is obtained by inducing the twistor structure of 12-D twistor space using dimensional reduction. The dimensionally reduced 6-D Kähler action is sum of 4-D Kähler action and volume term having interpretation in terms of a dynamical cosmological constant depending on the size scale of space-time surface (or of causal diamond CD in zero energy ontology (ZEO)) and determined by the representation of twistor sphere of space-time surface in the Cartesian product of the twistor spheres of M^4 and CP_2.

2. The preferred extremal property as a representation of quantum criticality would naturally correspond to minimal surface property meaning that the space-time surface is separately an extremal of both Kähler action and volume term almost everywhere so that there is no coupling between them. This is the case for all known extremals of Kähler action with non-vanishing induced Kähler form.

   Minimal surface property could however fail at 2-D string world sheets, their boundaries and perhaps also at partonic 2-surfaces. The failure is realized in minimal sense if the 3-surface has 1-D edges/folds (strings) and 4-surface 2-D edges/folds (string world sheets) at which some partial derivatives of the embedding space coordinates are discontinuous but canonical momentum densities for the entire action are continuous.

   There would be no flow of canonical momentum between interior and string world sheet and minimal surface equations would be satisfied for the string world sheet, whose 4-D counterpart in twistor bundle is determined by the analog of 4-D Kähler action. These conditions allow the transfer of canonical momenta between Kähler- and volume degrees of freedom at string world sheets. These no-flow conditions could hold true at least asymptotically (near the boundaries of CD).

   $M^8 - H$ duality suggests that string world sheets (partonic 2-surfaces) correspond to images of complex 2-sub-manifolds of M^8 (having tangent (normal) space which is complex 2-plane of octonionic M^8).

3. Cosmological constant would depend on p-adic length scales and one ends up to a concrete model for the evolution of cosmological constant as a function of p-adic length scale and other number theoretic parameters (such as Planck constant as the order of Galois group): this conforms with the earlier picture.

   Inflation is replaced with its TGD counterpart in which the thickening of cosmic strings to flux tubes leads to a transformation of Kähler magnetic energy to ordinary and dark matter. Since the increase of volume increases volume energy, this leads rapidly to energy minimum at some flux tube thickness. The reduction of cosmological constant by a phase transition

however leads to a new expansion phase. These jerks would replace smooth cosmic expansion of GRT. The discrete coupling constant evolution predicted by the number theoretical vision could be understood as being induced by that of cosmological constant taking the role of cutoff parameter in QFT picture [L71].

Twistor lift at the level of scattering amplitudes and connection with Veneziano duality

The classical part of twistor lift of TGD is rather well-understood. Concerning the twistorialization at the level of scattering amplitudes the situation is much more difficult conceptually - I already mentioned my limited QFT skills.

1. From the classical picture described above it is clear that one should construct the 8-D twistorial counterpart of theory involving space-time surfaces, string world sheets and their boundaries, plus partonic 2-surfaces and that this should lead to concrete expressions for the scattering amplitudes.

   The light-like boundaries of string world sheets as carriers of fermion numbers would correspond to twistors as they appear in twistor Grassmann approach and define the analog for the massless sector of string theories. The attempts to understand twistorialization have been restricted to this sector.

2. The beautiful basic prediction would be that particles massless in 8-D sense can be massive in 4-D sense. Also the infrared cutoff problematic in twistor approach emerges naturally and reduces basically to the dynamical cosmological constant provided by classical twistor lift.

   One can assign 4-momentum both to the spinor harmonics of the embedding space representing ground states of super-conformal representations and to light-like boundaries of string world sheets at the orbits of partonic 2-surfaces. The two four-momenta should be identical by quantum classical correspondence: this could be seen as a concretization of Equivalence Principle. Also a connection with string model emerges.

3. As far as symmetries are considered, the picture looks rather clear. Ordinary twistor Grassmannian approach boils down to the construction of scattering amplitudes in terms of Yangian invariants for conformal group of M^4. Therefore a generalization of super-symplectic symmetries to their Yangian counterpart seems necessary. These symmetries would be gigantic but how to deduce their implications?

4. The notion of positive Grassmannian is central in the twistor approach to the scattering amplitudes in $calN = 4$ SUSYs. TGD provides a possible generalization and number theoretic interpretation of this notion. TGD generalizes the observation that scattering amplitudes in twistor Grassmann approach correspond to representations for permutations. Since 2-vertex is the only fermionic vertex in TGD, OZI rules for fermions generalizes, and scattering amplitudes are representations for braidings.

   Braid interpretation encourages the conjecture that non-planar diagrams can be reduced to ordinary ones by a procedure analogous to the construction of braid (knot) invariants by gradual un-braiding (un-knotting).

   This is however not the only vision about a solution of non-planarity. Quantum criticality provides different view leading to a totally unexpected connection with string models, actually with the Veneziano duality, which was the starting point of dual resonance model in turn leading via dual resonance models to super string models.

1. Quantum criticality in TGD framework means that coupling constant evolution is discrete in the sense that coupling constants are piecewise constant functions of length scale replaced by dynamical cosmological constant. Loop corrections would vanish identically and the recursion formulas for the scattering amplitudes (allowing only planar diagrams) deduced in twistor Grassmann would involve no loop corrections. In particular, cuts would be replaced by sequences of poles mimicking them like sequences of point charge mimic line charges. In momentum discretization this picture follows automatically.

2. This would make sense in finite measurement resolution realized in number theoretical vision by number-theoretic discretization of the space-time surface (cognitive representation) as points with coordinates in the extension of rationals defining the adele [L51]. Similar discretization would take place for momenta. Loops would vanish at the level of discretization but what would happen at the possibly existing continuum limit: does the sequence of poles integrate to cuts? Or is representation as sum of resonances something much deeper?

3. Maybe it is! The basic idea of behind the original Veneziano amplitudes (see `http://tinyurl.com/yyhwvbqb`) was Veneziano duality. This 4-particle amplitude was generalized by Yoshiro Nambu, Holber-Beck Nielsen, and Leonard Susskind to N-particle amplitude (see `http://tinyurl.com/yyvkx7as`) based on string picture, and the resulting model was called dual resonance model. The model was forgotten as QCD emerged. Later came superstring models and led to M-theory. Now it has become clear that something went wrong, and it seems that one must return to the roots. Could the return to the roots mean a careful reconsideration of the dual resonance model?

4. Recall that Veneziano duality (1968) was deduced by assuming that scattering amplitude can be described as sum over s-channel resonances or t-channel Regge exchanges and Veneziano duality stated that hadronic scattering amplitudes have representation as sums over s- or t-channel resonance poles identified as excitations of strings. The sum over exchanges defined by t-channel resonances indeed reduces at larger values of s to Regge form.

   The resonances had zero width, which was not consistent with unitarity. Further, there were no counterparts for the *sum* of s-, t-, and u-channel diagrams with continuous cuts in the kinematical regions encountered in QFT approach. What puts bells ringing is the u-channel diagrams would be non-planar and non-planarity is the problem of twistor Grassmann approach.

5. Veneziano duality is true only for s- and t- channels but not been s- and u-channel. Stringy description makes t-channel and s-channel pictures equivalent. Could it be that in fundamental description u-channels diagrams cannot be distinguished from s-channel diagrams or t-channel diagrams? Could the stringy representation of the scattering diagrams make u-channel twist somehow trivial if handles of string world sheet representing stringy loops in turn representing the analog of non-planarity of Feynman diagrams are absent? The permutation of external momenta for tree diagram in absence of loops in planar representation would be a twist of π in the representation of planar diagram as string world sheet and would not change the topology of the string world sheet and would not involve non-trivial world sheet topology.

   For string world sheets loops would correspond to handles. The presence of handle would give an edge with a loop at the level of 3-surface (self energy correction in QFT). Handles are not allowed if the induced metric for the string world sheet has Minkowskian signature. If the stringy counterparts of loops are absent, also the loops in scattering amplitudes should be absent.

   This argument applies only inside the Minkowskian space-time regions. If string world sheets are present also in Euclidian regions, they might have handles and loop corrections could emerge in this manner. In TGD framework strings (string world sheets) are identified to 1-D edges/folds of 3-surface at which minimal surface property and topological QFT property fails (minimal surfaces as calibrations). Could the interpretation of edge/fold as discontinuity of some partial derivatives exclude loopy edges: perhaps the branching points would be too singular?

A reduction to a sum over s-channel resonances is what the vanishing of loops would suggest. Could the presence of string world sheets make possible the vanishing of continuous cuts even at the continuum limit so that continuum cuts would emerge only in the approximation as the density of resonances is high enough?

The replacement of continuous cut with a sum of *infinitely* narrow resonances is certainly an approximation. Could it be that the stringy representation as a sum of resonances with *finite* width is an essential aspect of quantum physics allowing to get rid of infinities necessarily accompanying loops? Consider now the arguments against this idea.

1. How to get rid of the problems with unitarity caused by the zero width of resonances? Could *finite* resonance widths make unitarity possible? Ordinary twistor Grassmannian approach predicts that the virtual momenta are light-like but complex: obviously, the imaginary part of the energy in rest frame would have interpretation as resonance with.

   In TGD framework this generalizes for 8-D momenta. By quantum-classical correspondence (QCC) the classical Noether charges are equal to the eigenvalues of the fermionic charges in Cartan algebrable (maximal set of mutually commuting observables) and classical TGD indeed predicts complex momenta (Kähler coupling strength is naturally complex). QCC thus supports this proposal.

2. Sum over resonances/exchanges picture is in conflict with QFT picture about scattering of particles. Could *finite* resonance widths due to the complex momenta give rise to the QFT type scattering amplitudes as one develops the amplitudes in Taylor series with respect to the resonance width? Unitarity condition indeed gives the first estimate for the resonance width.

   QFT amplitudes should emerge in an approximation obtained by replacing the discrete set of finite width resonances with a cut as the distance between poles is shorter than the resolution for mass squared.

   In superstring models string tension has single very large value and one cannot obtain QFT type behavior at low energies (for instance, scattering amplitudes in hadronic string model are concentrated in forward direction). TGD however predicts an entire hierarchy of p-adic length scales with varying string tension. The hierarchy of mass scales corresponding roughly to the lengths and thickness of magnetic flux tubes as thickened cosmic strings and characterized by the value of cosmological constant predicted by twistor lift of TGD. Could this give rise to continuous QCT type cuts at the limit when measurement resolution cannot distinguish between resonances?

   The dominating term in the sum over sums of resonances in t-channel gives near forward direction approximately the lowest mass resonance for strings with the smallest string tension. This gives the behavior $1/(t - m_{min}^2)$, where m_{min} corresponds to the longest mass scale involved (the largest space-time sheet involved), approximating the $1/t$-behavior of massless theories. This also brings in IR cutoff, the lack of which is a problem of gauge theories. This should give rise to continuous QFT type cuts at the limit when measurement resolution cannot distinguish between resonances.

1.2 Bird's Eye of View about the Topics of the Book

1.2.1 Organization of "TGD and Quantum Biology: Part I"

The book "TGD and Quantum Biology: Part I" represents the general ideas of TGD inspired quantum biology and discusses soem applications. The book consists of three parts.

1. The first part begins with a chapter, which introduces the notion of a magnetic body carrying dark matter in the TGD sense. There is a chapter about general problems of physics, biology and neuroscience challenging the recent "biology as nothing but chemistry" view. The notion of the magnetic body acting as controller of ordinary matter is universal and challenges the view that only biological systems can be living and conscious and a chapter about the dance of honeybee is included.

2. The second part the notion of a magnetic body is discussed at a more detailed level and a model of bio-superconductivity relying on these notions is discussed.

3. In the third part some applications are considered. There are 3 chapters about possible implications of dark matter at the level of biomolecules. The most important applications are related to biocatalysis and molecular signalling. A chapter about protein folding is included because I did not have the heart to throw it away. There are two chapters about the role of dark photons as a source of bio-photons. There is also a chapter about the possible role of dark valence electrons in biology.

1.3   Sources

The eight online books about TGD [K121, K115, K97, K78, K28, K76, K54, K107] and nine online books about TGD inspired theory of consciousness and quantum biology [K113, K24, K85, K22, K51, K61, K65, K106, K112] are warmly recommended for the reader willing to get overall view about what is involved.

My homepage (`http://tinyurl.com/ybv8dt4n`) contains a lot of material about TGD. In particular, a TGD glossary at `http://tinyurl.com/yd6jf3o7`).

I have published articles about TGD and its applications to consciousness and living matter in *Journal of Non-Locality* (`http://tinyurl.com/ycyrxj4o` founded by Lian Sidorov and in *Prespacetime Journal* (`http://tinyurl.com/ycvktjhn`), *Journal of Consciousness Research and Exploration* (`http://tinyurl.com/yba4f672`), and *DNA Decipher Journal* (`http://tinyurl.com/y9z52khg`), all of them founded by Huping Hu. One can find the list about the articles published at `http://tinyurl.com/ybv8dt4n`. I am grateful for these far-sighted people for providing a communication channel, whose importance one cannot overestimate.

1.3.1   PART I: GENERAL IDEAS

Quantum Mind, Magnetic Body, and Biological Body

The chapter is devoted to some applications of TGD inspired view about Quantum Mind to biology. Magnetic body carrying dark matter and forming an onionlike structure with layers characterized by large values of Planck constant is the key concept. Magnetic body is identified as intentional agent using biological body as sensory receptor and motor instrument. EEG is identified as a communication and control tool of the magnetic body and a fractal hierarchy of analogs of EEG is predicted.

Living system is identified as a kind of Indra's net with biomolecules representing the nodes of the net and magnetic flux tubes connections between then. The reconnection of magnetic flux tubes and phase transitions changing Planck constant and therefore the lengths of the magnetic flux tubes are identified as basic mechanisms behind DNA replication and analogous processes and also behind the phase transitions associated with the gel phase in cell interior. The braiding of magnetic flux makes possible universal memory representation recording the motions of the basic units connected by flux tubes. Braiding also defines topological quantum computer programs updated continually by the flows of the basic units. The model of DNA as topological quantum computer is discussed as an application.

A vision about quantum metabolism in TGD Universe is proposed. The new element is the idea that the presence of ATP at magnetic flux tube is a necessary prerequisite for negentropic entanglement between its ends. ATP could be seen as a molecule of consciousness in this picture. Also a possible modification of second law to take into account negentropic entanglement is discussed. TGD approach to living matter was strongly motivated by the findings about strange behavior of cell membrane and of cellular water, and gel behavior of cytoplasm. These findings are briefly discussed in TGD framework by bringing in magnetic flux tubes as a new element. Water is in key role in living matter and TGD inspired view about water and its anomalies is discussed.

TGD Based View about Classical Fields in Relation to Consciousness Theory and Quantum Biology

In TGD Universe gauge fields are replaced with topological field quanta. Examples are topological light rays, magnetic/electric flux tubes and sheets, and flux quanta carrying both magnetic and electric fields. Flux quanta form a fractal hierarchy in the sense that there are flux quanta inside flux quanta. It is natural to assume quantization of Kähler magnetic flux. Braiding and reconnection are the basic topological operations for flux quanta.

The basic question is how the basic notions assigned with the classical gauge and gravitational fields understood in standard sense generalize in TGD framework.

1. Superposition and interference of the classical fields is very natural in Maxwell electrodynamics and certainly experimentally verified phenomena. Also the notion of hologram relies crucially on the notion of interference. How can one describe the effects explained in terms

of superposition of fields in a situation in which the theory is extremely non-linear and all classical gauge fields are expressible in terms of CP_2 coordinates and their gradients? It is also rather clear that the preferred extremals for Kähler action decompose to space-time regions representing space-time correlates for quanta. The superposition of classical fields in Maxwellian sense is impossible.

How can one cope with this situation? The answer is based on simple observation: only the *effects* of the classical fields superpose. There is no need for the fields to superpose. Together with the notion of many-sheeted space-time this leads to elegant description of interference effects without any need to assume that linearization is a good approximation.

2. Topological quantization brings in also braiding and reconnection of magnetic flux tubes as basic operations for classical fields. These operations for flux tubes have also Maxwellian counterparts at the level of field lines. Braiding and reconnection are in a central role in TGD Universe and especially so in in TGD inspired theory of consciousness and quantum biology. The challenge is to build a coherent overall phenomenological view about the role of topologically quantized classical fields in biology and neuroscience. For instance, one can ask what is the precise formulation for the notion of conscious hologram and whether magnetic flux tubes could serve as correlates of entanglement (or at least negentropic entanglement suggested by the number theoretic vision and identified as a basic signature of living matter).

3. Topological quantization and the notion of magnetic body are especially important in TGD inspired model of EEG. The attempt to understand the findings of Persinger from the study of what is known as God helmet leads to a considerable progress in the understanding the possible role of topologically quantized classical fields in biology and neuro-science.

Getting philosophical: some comments about the problems of physics, neuroscience, and biology

In this chapter I summarize what I see as the basic philosophical problems of the recent conceptual framework of biology and neuroscience and discuss how TGD can resolve these problems. One cannot actually avoid the problems of fundamental physics and of consciousness theory so that also these are discussed to some degree. Also concrete mechanisms are discussed with aim to give an overall view about TGD inspired quantum biology.

Can quantum biology really do without new physics?

Quantum biology is now taken rather seriously. Photosynthesis and avian navigation are two key applications of quantum biology. The basic problem in both cases is posed by the fact that the magnetic interaction energy in Earth's magnetic field is roughly million times smaller than thermal energy. The so called radical-pair mechanism (RPM) was proposed already at 60's as a possible solution to the problem posed by anomalously large effect in EPR and NMR experiments. According to RPM, a radical pair is accompanied by electron pair, which is in a superposition of spin triplet and singlet states and behaves as quantum coherent system for a time sufficiently long to induce chemical effects. The hyperfine interaction of the members of the electron pair with the nuclei of radicals would amplify the effect. The neutralization of radical pair puts an end to the coherence interaction period.

The proposal is that RPM gives rise to chemical compass making possible avian navigation. There is however a problem. RPM has been observed in laboratory only for magnetic fields in the range 1 mT- 10 T. Earth's magnetic field is only 2 per cent of the lower bound so that it is quite possible that RPM is not at work.

This opens up the door for new quantum physics proposed by TGD based model of quantum biology. In this approach magnetic body acts as as intentional agent using biological body as a sensory receptor and motor instrument. Macroscopic quantum coherence is made possible by dark matter realized as a hierarchy of $h_{eff} = n \times h$ phases.

In this chapter RMP is summarized and compared with the TGD based vision. Also the possible connection between avian navigation and circadian clock suggested by the fact that both involve photoreceptor known as cryptocrome and a possible connection with gravitaxis are considered in TGD framework.

1.3.2 PART II: THE NOTION OF MAGNETIC BODY AND BIO-SUPERCONDUCTIVITY

Dark Forces and Living Matter

The unavoidable presence of classical long ranged weak (and also color) gauge fields in TGD Universe has been a continual source of worries for more than two decades. The basic question has been whether electro-weak charges of elementary particles are screened in electro-weak length scale or not. The TGD based view about dark matter assumes that weak charges are indeed screened for ordinary matter in electro-weak length scale but that dark electro-weak bosons correspond to much longer symmetry breaking length scale. The localization of the modes of Kähler-Dirac action to 2-D surfaces at which W fields vanish realizes this idea concretely. Also Z^0 fields can vanish and are expected to do so above weak scale.

The large value of $\hbar$ in dark matter phase implies that Compton lengths and -times are scaled up. In particular, the sizes of nucleons and nuclei become of order atom size so that dark nuclear physics would have direct relevance for condensed matter physics. It becomes impossible to make a reductionistic separation between nuclear physics and condensed matter physics and chemistry anymore. This view forces a profound re-consideration of the earlier ideas in nuclear and condensed physics context. It however seems that most of the earlier ideas related to the classical Z^0 force and inspired by anomaly considerations survive in a modified form.

The weak form of electric-magnetic duality led to the identification of the long sought for mechanism causing the weak screening in electroweak scales. The basic implication of the duality is that Kähler electric charges of wormhole throats representing particles are proportional to Kähler magnetic charges so that the CP_2 projections of the wormhole throats are homologically non-trivial. The Kähler magnetic charges do not create long range monopole fields if they are neutralized by wormhole throats carrying opposite monopole charges and weak isospin neutralizing the axial isospin of the particle's wormhole throat. One could speak of confinement of weak isospin. The weak field bodies of elementary fermions would be replaced with string like objects with a length of order W boson Compton length. Electro-magnetic flux would be fed to electromagnetic field body where it would be fed to larger space-time sheets. Similar mechanism could apply in the case of color quantum numbers. Weak charges would be therefore screened for ordinary matter in electro-weak length scale but dark electro-weak bosons correspond to much longer symmetry breaking length scale for weak field body. Large values of Planck constant would make it possible to zoop up elementary particles and study their internal structure without any need for gigantic accelerators.

One can still worry about large parity breaking effects - say in nuclear physics- since the couplings of spinors to classical weak fields are there. Around 2012 it became clear that the condition that induced spinor fields have well defined em charge localizes their modes in the generic case to 2-surfaces carrying vanishing induced W gauge fields. It is quite possible that this localization is consistent with Kähler-Dirac equation only in ther Minkowskian regions were the effective metric defined by Kähler-Dirac gamma matrices can be effectively 2-dimensional.

On can pose the additional condition that also classical Z^0 field vanishes - at least above weak scale. Fundamental fermions would experience only em field so that the worries related to large parity breaking effects would disappear. The proportionality of weak scale to $h_{eff} = n \times h$ however predicts that weak fields are effectively massless belong scaled up weak scale. Therefore worries about large parity breaking effects in ordinary nuclear physics can be forgotten.

In this chapter possible implications of the dark weak force for the understanding of living matter are discussed. The basic question is how classical Z^0 fields could make itself visible. Large parity breaking effects in living matter suggests which direction one should look for the answer to the question. One possible answer is based on the observation that for vacuum extremals classical electromagnetic and Z^0 fields are proportional to each other and this means that the electromagnetic charges of dark fermions standard are replaced with effective couplings in which the contribution of classical Z^0 force dominates. This modifies dramatically the model for the cell membrane as a Josephson junction and raises the scale of Josephson energies from IR range just above thermal threshold to visible and ultraviolet. The amazing finding is that the Josephson energies for biologically important ions correspond to the energies assigned to the peak frequencies in the biological activity spectrum of photoreceptors in retina suggesting. This suggests that almost

vacuum extremals and thus also classical Z^0 fields could be in a central role in the understanding of the functioning of the cell membrane and of sensory qualia. This would also explain the large parity breaking effects in living matter.

A further conjecture is that EEG and its predicted fractally scaled variants which same energies in visible and UV range but different scales of Josephson frequencies correspond to Josephson photons with various values of Planck constant. The decay of dark ELF photons with energies of visible photons would give rise to bunches of ordinary ELF photons. Biophotons in turn could correspond to ordinary visible photons resulting in the phase transition of these photons to photons with ordinary value of Planck constant. This leads to a very detailed view about the role of dark electromagnetic radiation in biomatter and also to a model for how sensory qualia are realized. The general conclusion might be that most effects due to the dark weak force are associated with almost vacuum extremals.

Magnetic Sensory Canvas Hypothesis

There are very general objections against the idea that ultimate sensory representations are realized inside brain. For instance, any computer scientist, unless informed about materialistic dogmas, would argue that the processing of the sensory data must be separated from its representation. How this could occur if sensory and other representations are realized inside brain, is however difficult to see.

In TGD approach these objections lead to the view that the magnetic flux tube structures associated with the primary sensory organs and higher levels of central nervous system define a hierarchy of sensory and other representations outside brain with magnetic flux tubes serving as the sensory canvas to which place coding by magnetic transition frequencies generates sensory subselves and associates with them various sensory qualia and features by quantum entanglement. Thus brain could be much like a RAM memory containing a collection of features in random order and the ordering would be induced by the sensory map to the magnetic sensory canvas. MEs define the sensory projections and EEG MEs correspond to our level in this hierarchy of projections. The sizes of these sensory selves are of order ME sizes ($L(EEG) = c/f(EEG)$) and thus or order Earth size at least. Thus TGD based view about sensory representations is a diametrical opposite of the standard view in which sensory representations are miniatures.

The construction of a more detailed model is based on the following assumptions.

1. Sensory qualia are at the level of primary sensory organs having their own magnetic bodies and entangled with the cognitive and symbolic representations of the perceptive field in brain in turn entangled with the points of the sensory magnetic canvas. The entanglement between primary sensory organs and brain and TGD based view about long term memory resolves the basic objections against this view, and one can understand the differences between sensory experience, imagination, dreams, and hallucinations and various strange phenomena like synesthesia, Anton's syndrome, and blind sight.

2. Second essential element is the mirror mechanism of long term memories. To remember something in the geometric past at temporal distance T is to look at a magnetic mirror with length $L = cT/2$. At quantum level quantum entanglement is involved and means sharing of mental images between recent me and the me of the geometric past (or some other self responsible for the memory representations). This requires that magnetic flux tubes involved with long term memories have astrophysical lengths with light year being the natural length unit. For magnetic fields this indeed makes sense. This picture can be applied to construct a model of long term episodal and declarative memories. The magnetic body (the "me") uses brain as a time mirror by generating a negative energy ME representing a signal propagating along magnetic flux tube to the brain and entangling magnetic body with brain. The negative energy ME is time reflected as a positive energy ME able to communicate classical information to the magnetic body possibly using p-adic cognitive code. Phase conjugate laser wave is the physical counterpart of negative energy ME.

   Zero energy ontology (ZEO) has provided a justification and precise definition for the notion of negative energy signal at quantum level. The arrow of time and negative energy have as quantum correlate the boundary of CD at which the state remains invariant under repeated state function reductions which in ordinary quantum theory would leave the state invariant.

3. Libet's findings about strange causal anomalies related to the passive aspects of consciousness support strongly the notion of magnetic body and lead to the conclusion that sensory experiences are geometric memories of magnetic body in time scale of .5 seconds about what happens in at the level of material body. Libet's findings about active aspects of consciousness in turn allow to conclude that motor activity is very much like active precognition and mirror image of sensory perception. A beautiful general scenario unifying sensory perception, long term memories, and motor action emerges and allows to explain phenomena like sensory rivalry difficult to understand in neuro-science framework. It must be however admitted that sensory canvas hypothesis is far from being established even in TGD framework: one can also defend the minimal model in which personal magnetic body is responsible only for the realization of long term memories and sensory, symbolic, and cognitive representations are realized only at the level of the material body.

4. Dark matter hierarchy based on a hierarchy of increasing values of Planck constant predicts a hierarchy of generalized EEGs. The generalized EEGs make it possible for the magnetic bodies to receive sensory information from biological body and quantum control it. The resulting detailed model of ordinary EEG predicts correctly the band structure and narrow resonance bands.

Quantum Model for Bio-Superconductivity: I

The model for generalized EEG relates very closely to the general model of high T_c superconductivity. This motivates a separate discussion of the vision about bio-super-conductivity in TGD Universe.

1. General mechanisms of bio-superconductivity

The many-sheeted space-time concepts suggested a very general mechanism of superconductivity based on the "dropping" of charged particles from atomic space-time sheets to larger space-time sheets. The first guess was that larger space-time sheets are very dry, cool and silent so that the necessary conditions for the formation of high T_c macroscopic quantum phases are met. The criticism against "dropping" is that particle can topologically condense on several space-time sheets which therefore are not separate worlds: this is indeed assumed in the recent view about GRT and QFT limit of TGD. Dropping could therefore occur only at larger space-time sheet at the boundary of the smaller one. The expansion of the space-time sheet (flux tube) in p-adic phase transition liberates also zero point kinetic energy (cyclotron energy).

The possibility of large $\hbar$ quantum coherent phases makes the assumption about thermal isolation between space-time sheets un-necessary. The establishment of thermal equilibrium would rely on the phase transitions transforming ordinary to dark matter and vice versa. Biophotons could be produced from dark photons in this manner. The flow from a flux tube portion with larger value of h_{eff} to that with a smaller value liberates cyclotron energy.

A crucial element is quantum criticality predicting a new kind of superconductivity explaining the strange features of high T_c super-conductivity. This led to the proposal that there are two kinds of Cooper pairs, exotic Cooper pairs with spin $S = 1$ and counterparts of ordinary BCS type Cooper pairs with spin $S = 0$. Both correspond to a large value of Planck constant. Exotic Cooper pairs are quantum critical meaning that they can decay to ordinary electrons. Below temperature $T_{c_1} > T_c$ only exotic Cooper pairs with spin are present and their finite lifetime implies that super-conductivity is broken to ordinary conductivity satisfying scaling laws characteristic for criticality. At T_c spinless BCS type Cooper pairs become stable and exotic Cooper pairs can decay to them and vice versa. An open question is whether the BCS type Cooper pairs can be present also in the interior of cell.

These two superconducting phases would compete in certain narrow interval around critical temperature for which body temperature of endotherms is a good candidate in the case of living matter. Also high T_c superfluidity of bosonic atoms dropped to space-time sheets of electronic Cooper pairs becomes possible besides ionic super conductivity. Even dark neutrino superconductivity can be considered below the weak length scale of scaled down weak bosons.

Magnetic flux tubes would be carriers of dark particles and magnetic fields would be crucial for super-conductivity. Two parallel flux tubes carrying magnetic fluxes in opposite directions is

the simplest candidate for super-conducting system. This conforms with the observation that anti-ferromagnetism is somehow crucial for high temperature super-conductivity. The spin interaction energy is proportional to Planck constant and can be above thermal energy: if the hypothesis that dark cyclotron energy spectrum is universal is accepted, then the energies would be in bio-photon range and high temperature super-conductivity is obtained. If fluxes are parallel spin $S = 1$ Cooper pairs are stable. $L = 2$ states are in question since the members of the pair are at different flux tubes. These two kinds of Cooper pairs could correspond to BCS type and exotic Cooper pairs.

The fact that the critical magnetic fields can be very weak or large values of $\hbar$ is in accordance with the idea that various almost topological quantum numbers characterizing induced magnetic fields provide a storage mechanism of bio-information.

This mechanism is extremely general and in principle works for electrons, protons, ions, charged molecules and even exotic neutrinos and an entire zoo of high T_c bio-superconductors, super-fluids and Bose-Einstein condensates is predicted. Of course, there are restrictions due to the thermal stability it room temperature and it seems that only electron, neutrino, and proton Cooper pairs are possible at room temperature besides Bose-Einstein condensates of all bosonic ions and their exotic counterparts resulting when some nuclear color bonds become charged.

2. Hierarchies of preferred p-adic length scales and values of Planck constant

TGD inspired quantum biology and number theoretical considerations suggest preferred values for $r = \hbar/\hbar_0$. For the most general option the values of $\hbar$ are products and ratios of two integers n_a and n_b. Ruler and compass integers defined by the products of distinct Fermat primes and power of two are number theoretically favored values for these integers because the phases $exp(i2\pi/n_i)$, $i \in \{a, b\}$, in this case are number theoretically very simple and should have emerged first in the number theoretical evolution via algebraic extensions of p-adics and of rationals. p-Adic length scale hypothesis favors powers of two as values of r.

The hypothesis that Mersenne primes $M_k = 2^k - 1$, $k \in \{89, 107, 127\}$, and Gaussian Mersennes $M_{G,k} = (1 + i)k - 1$, $k \in \{113, 151, 157, 163, 167, 239, 241..\}$ (the number theoretical miracle is that all the four p-adic length scales sith $k \in \{151, 157, 163, 167\}$ are in the biologically highly interesting range 10 nm-2.5 μm) define scaled up copies of electro-weak and QCD type physics with ordinary value of $\hbar$ and that these physics are induced by dark variants of corresponding lower level physics leads to a prediction for the preferred values of $r = 2^{k_d}$, $k_d = k_i - k_j$, and the resulting picture finds support from the ensuing models for biological evolution and for EEG. This hypothesis - to be referred to as Mersenne hypothesis - replaces the earlier rather ad hoc proposal $r = \hbar/\hbar_0 = 2^{11k}$ for the preferred values of Planck constant.

3. Fractal hierarchy of magnetic flux sheets and the hierarchy of genomes

The notion of magnetic body is central in the TGD inspired theory of living matter. Every system possesses magnetic body and there are strong reasons to believe that the magnetic body associated with human body is of order Earth size and that there could be an entire hierarchy of these bodies with even much larger sizes. Therefore the question arises what one can assume about these magnetic bodies. The quantization of magnetic flux suggests an answer to this question.

1. The quantization condition for magnetic flux reads in the most general form as $\oint (p - eA) \cdot dl = n\hbar$. If supra currents flowing at the boundaries of the flux tube are absent one obtains $e \int B \cdot dS = n\hbar$, which requires that the scaling of the Planck constant scales up the flux tube thickness by r^2 and scaling of B by $1/r$. If one assumes that the radii of flux tubes do not depend on the value of r, magnetic flux is compensated by the contribution of the supra current flowing around the flux tube: $\oint (p - eA) \cdot dl = 0$. The supra currents would be present inside living organism but in the faraway region where flux quanta from organism fuse together, the quantization conditions $e \int B \cdot dS = n\hbar$ would be satisfied.

2. From the point of view of EEG especially interesting are the flux sheets which have thickness $L(151) = 10$ nm (the thickness of cell membrane) carrying magnetic field having strength of endogenous magnetic field. In absence of supra currents these flux sheets have very large total transversal length proportional to r^2. The condition that the values of cycloctron energies are above thermal energy implies that the value of r is of order 2^{k_d}, $k_d = 44$. Strongly folded flux sheets of this thickness might be associated with living matter and connect their DNAs

to single coherent structure. One can of course assume the presence of supra currents but outside the organism the flux sheet should fuse to form very long flux sheets.

3. Suppose that the magnetic flux flows in head to tail direction so that the magnetic flux arrives to the human body through a layer of cortical neurons. Assume that the flux sheets traverse through the uppermost layer of neurons and also lower layers and that DNA of each neuronal nuclei define a transversal sections organized along flux sheet like text lines of a book page. The total length of DNA in single human cell is about one meter. It seems that single organism cannot provide the needed total length of DNA if DNA dominates the contribution. This if of course not at all necessarily since supra currents are possible and outside the organism the flux sheets can fuse together. This implies however correlations between genomes of different cells and even different organisms.

These observations inspire the notion of super- and hyper genes. As a matter fact, entire hierarchy of genomes is predicted. Super genes consist of genes in different cell nuclei arranged to threads along magnetic flux sheets like text lines on the page of book whereas hyper genes traverse through genomes of different organisms. Super and hyper genes provide an enormous representative capacity and together with the dark matter hierarchy allows to resolve the paradox created by the observation that human genome does not differ appreciably in size from that of wheat.

Quantum Model for Bio-Superconductivity: II

The models for EEG and its variants and for nerve pulse rely on a general model of high T_c superconductivity. The general vision behind model of cell membrane as super-conductor inspired by the identification of dark matter in terms of hierarchy of Planck constants and the notion of magnetic body was considered in the previous chapter. In this chapter the vision is tested by applying it to various anomalous findings about the behavior of the cell membrane.

The topics discussed are following.

1. There are several findings challenging the standard thermodynamical view about cell membrane. TGD suggests a model in which various transmembrane proteins (receptors, channels, pumps) act as Josephson junction between superconductors assignable to the interior and exterior of cell membrane.

   The most feasible model for cell membrane and charge transfer found hitherto relies on Pollack's observations about fourth gel like phase of water. The model for the findings leads to a generalization of the cell membrane as Josephson junction obtained by adding to Josephson energy the difference of the cyclotron energies of dark ion at two sides of the cell membrane. Cyclotron energy difference replaces chemical potential difference in the generalization of the thermodynamical model inspired by Zero Energy Ontology, and replacing thermodynamical distributions with their quantal "square roots". Charge transfer would be induced by a phase transition changing the value of Planck constant at either or both sides of the membrane. This would induce the change of the equilibrium concentrations of ions and also charge transfer.

2. Water memory, chiral selection of biomolecules, burning of water by radiowaves represent further intriguing effects whose understanding seems to require new physics. Dark matter identified in term of hierarchy of Planck constants and the notion of magnetic body define an attractive candidate in this respect. Scaled up variants of weak physics defined by the hierarchy of Planck constants and p-adic length scale hierarchy could explain chiral selection.

3. Hafedh Abdelmelek and collaborators have found evidence for effective super-conductivity in the sciatic nerves of both endotherms (rabbit) and poikilotherms (frog). The TGD based explanation would be in terms of dark supra currents.

4. DC currents of Becker have been known for a long time. An attractive interpretation is as supra currents. The basic prediction is that the resistance should not depend on he length of the conduction pathway. One can also construct a quantum model for the current.

5. TGD inspires two views about cell membrane which need not be contradictory. For the first model cell is far from vacuum extremal, for the second model nearly vacuum extremal. There are several constraints on the model coming from the TGD based identification of bio-photons, the new view about metabolism. It seem that that the first model might be enough when generalized along lines inspired by Pollack's findings about the fourth phase of water.

Physicists M. Tajmar and C. J. Matos and their collaborators working in ESA (European Satellite Agency) have made an amazing claim of having detected strong gravimagnetism with gravimagnetic field having a magnitude which is about 20 orders of magnitude higher than predicted by General Relativity.

Tajmar et al have proposed the gravimagnetic effect as an explanation of an anomaly related to the superconductors. The measured value of the mass of the Cooper pair is slightly larger than the sum of masses whereas theory predicts that it should be smaller. The explanation would be that actual Thomson field is larger than it should be because of gravimagnetic contribution to quantization rule used to deduce the value of Thomson field. The required value of gravimagnetic Thomson field is however 28 orders of magnitude larger than General Relativity suggests. TGD inspired proposal is based on the notion of gravitational Planck constant assignable to the flux tubes connecting to massive objects. It turns out that the TGD estimate for the Thomson field has correct order of magnitude. The identification $h_{eff} = h_{gr}$ at particle physics and atomic length scales emerges naturally.

A vision about the fundamental role of quantum gravitation in living matter emerges. The earlier hypothesis that dark EEG photons decay to biophotons with energies in visible and ultraviolet range receives strong quantitative support. Also a mechanism for how magnetic bodies couple bio-chemistry emerges. The vision conforms with Penrose's intuitions about the role of quantum gravity in biology.

1.3.3   PART III: DARK MATTER AND QUANTUM BIOLOGY

The based view about dark matter at the level of molecular biology

The notion of dark matter as phases of ordinary matter with effective Planck constant $h_{eff} = nh_0$ is the basic prediction of the number theoretic vision about Topological Geometrodynamics (TGD). This article is devoted to the possible role of magnetic body (MB) and dark matter in the TGD sense in chemistry and biology.

The first group of questions relates to the role dark protons and electrons, in ordinary chemistry and organic chemistry. Could the protons donated by acids be dark? What about the protons associated with hydrogen bonds? What about biologically important ions? What about oxidation and reduction: are the electrons involved dark: do valence electrons have $h_{eff} > h$?

Second group of questions relates to the role of the magnetic body (MB) carrying dark matter in biochemistry. Does the transition to biochemistry involve Pollack effect in which the fraction 1/4 of protons becomes dark and is transferred to the magnetic flux tubes? Do dark protons organize into triplets forming analogs of DNA, RNA, tRNA, and amino-acids, and are their chemical representations only secondary representations, kind of mimicry?

Dark protons could neutralize the phosphates of DNA and RNA. Do they also neutralize the phosphates at the ends of the lipids of the cell membrane: does cell membrane realize genetic code? What about microtubules having GTPs associated with tubulins? ATP molecule has 3 units of charge: is it neutralized by dark proton triplet: could the energies of this triplet and dark valence electrons explain the high energy phosphate bond? Amino-acids should be accompanied by dark proton triplets: could the binding with dark electrons neutralize them?

Could basic biomolecules and their dark analogs interact by exchanging dark photons in energy resonance. Could bio-photons result from dark extremely low frequency (ELF) photons? Could energy resonance conditions select the basic biomolecules?

Molecular Signalling from the TGD Point of View

The findings of Elowitz et al lead to a formal model suggesting that ligands of type BMP (bone morphogenetic protein) have interactions. The interactions would be non-local so that it is difficult

to imagine that they could have chemical origin. The TGD based model for these long range interactions is based on dark photon resonance. For the simplest, receptors would correspond to fixed bio-harmonies. In a single ligand system the ligand would have the bio-harmony of its preferred receptor. The interaction between ligand magnetic bodies would be re-tuning and could replace the preferred bio-harmonies assignable to the participating ligands with distributions of bio-harmonies. Therefore the ligands of the multi-ligand system would couple by bio-resonance also to other than preferred receptors.

The model stimulates questions, which lead to a rather detailed model for the re-tuning and tuning processes at the level of codons and amino acids. The model suggests that the tuning to a given bioharmony for the dark counterparts of basic biomolecules and its stabilization involves epigenetic control based on the methylation of some special DNA and RNA nucleotides and amino-acids acting as analogs of tuning forks.

The proposal that bioharmonies are molecular correlates for emotions suggests that this process involves minimal number of methylations, which define the seed of phase transition to a bioharmony in the scale of the basic unit of genome (such as gene), mRNA sub-unit (splicing) and protein sub-unit.

A Model for Protein Folding and Bio-catalysis

The model for the evolution of genetic code leads to the idea that the folding of proteins obeys a folding code inherited from the genetic code. The flux connections between molecules containing dark matter in macroscopic quantum phase and characterized by two integers are the basic new physics element of the model.

After some trials one ends up with a general conceptualization of the situation with the identification o magnetic flux tubes as correlates of attention at molecular level so that a direct connection with TGD inspired theory of consciousness emerges at quantitative level. This allows a far reaching generalization of the DNA as topological quantum computer paradigm and makes it much more detailed. By their asymmetric character hydrogen bonds are excellent candidates for contracted magnetic flux tubes serving as correlates of attention at molecular level.

One can consider two models. For the first model the flux tubes between amino-acids are assumed to determine the protein folding.

1. The constant part of free amino-acid containing $O - H$, $O =$, and NH_2 would correspond to the codon XYZ in the sense that the flux tubes would carry the "color" representing the four nucleotides in terms of quark pairs. Color inheritance by flux tube reconnection makes this possible. For the amino-adics inside protein $O =$ and $N - H$ would correspond to YZ. Also flux tubes connecting the acceptor atoms of hydrogen bonds are required by the model of DNA as topological quantum computer. The long flux tubes between $O =$ atoms and their length reduction in a phase transition reducing Planck constant could be essential in protein-ligand interaction.

2. The model predicts a code for protein folding: depending on whether also $= O - O =$ flux tubes are allowed or not, $Y = Z$ or $Y = Z_c$ condition is satisfied by the amino-acids having $N - H - -O =$ hydrogen bond. For $= O - O =$ bonds $Y - Y_c$ pairing holds true. If one identifies hydrogen bond with flux tube ($Y(n) = Z(n + k)$) the model works badly for both options. If one assumes only that the presence of a flux tube connecting amino-acids in either direction ($Y(n) = Z(n + k)$ or $Z(n) = Y(n + k)$) is a prerequisite for the formation of hydrogen bond, the model works. $Y = Z_c$ option predicts the average length of alpha bonds correctly. $Y = Z$ rule is however favored by the study of alpha helices for four enzymes: the possible average length of alpha helix is considerably longer than the average length of alpha helix if gene is the unique gene allowing to satisfy $Y = Z$ rule. The explicit study of alpha helices for four enzymes demonstrates that the failure to satisfy the condition for the existence of hydrogen bond fails rarely and at most for two amino-acids (for 2 amino-acids in single case only). For beta sheets there ar no failures for $Y = Z$ option.

3. The information apparently lost in the many-to-one character of the codon-amino-acid correspondence would code for the folding of the protein and similar amino-acid sequences could give rise to different foldings. Also catalyst action would reduce to effective base pairing and

one can speak about catalyst code. The DNA sequences associated with alpha helices and beta sheets are completely predictable unless one assumes a quantum counterpart of wobble base pairing meaning that $N-H$ flux tubes are before hydrogen bonding in quantum super-positions of braid colors associated with the third nucleotides Z of codons XYZ coding for amino-acid. Only the latter option works. The outcome is very simple quantitative model for folding and catalyst action based on minimization of energy and predicting as its solutions alpha helices and beta strands.

Second model represents a diametrical opposite of the first model in the sense in that it assumes flux tube connections only between amino-acids and water molecules. These flux tubes mediate an attractive (repulsive) interaction in the case of hydrophily (hydrophoby) due to the behavior of magnetic (presumably) interaction energy as a function of Planck constant (or integers characterizing the level of dark matter) assignable to the flux tube. For hydrophoby (hydrophily) the interaction energy is minimized for long (short) flux tubes. The interaction between amino-acids is induced by this interaction in a manner analogous to how the interaction between electrons and ions induces secondary interaction between the members of a Cooper pair. The model explains the basic qualitative aspects of protein folding and the quantitative model of folding based on amino-acid-amino-acid flux tubes allows a generalization which is however discussed at numerical level.

The third proposal asks whether protein folding could be induced by the flux tube connections of protein with water's MB rather than between proteins as in the first two models. This model is certainly an idealization since S-S valence bonds are known to play an important part in the folding. These flux tube connections could be accompanied by hydrogen bonds - even longer than usual if h_{eff} as spectrum for water as has been proposed. This involves more detailed ideas about the origin of hydrophobia and hydrophilia at the level of magnetic body (MB). Hydrophilic amino acids would tend to form flux tube connections with the MB of water unlike hydrophobic amino acids. The formation of flux tube connection would serve as a correlate for attention at molecular level.

Decade after writing this chapter the vision about the role of DNA in TGD Universe evolved with inspiration coming from the model of water memory and homeopathy and the realization that homeopathy might represent a core elemement in the functioning of immune system involving new physics in an essential manner. The key idea is that dark variants of amino-acid sequences would have coded for the 2-braiding of the magnetic flux tube patterns defining invader molecule as a dynamical process: dark proteins would mimic physically the braiding of invader molecule's magnetic body. Dark DNA sequences would have coded this braiding symbolically and their translation to dark amino-acids would transform symbolic representation to a concrete physical one. The emergence of ordinary DNA and amino-acids would have realized the same at biochemical level and amino-acid sequences representing the invader would serve as antigene attaching to the invader molecule. Not only the pattern produced in protein folding but also the temporal pattern of protein folding would be coded by DNA.

Are dark photons behind biophotons?

TGD approach leads to a prediction that bio-photons result when dark photons with large value of effective Planck constant and large wavelength transform to ordinary photons with same energy. The recent progress in understanding the implications of basic vision behind TGD inspired theory of consciousness served as a particular motivation for developing a more detailed view about bio-photons.

1. The anatomy of quantum jump in zero energy ontology (ZEO) allows one to understand basic aspects of sensory and cognitive processing in the brain without ever mentioning the brain. Sensory perception - motor action cycle with motor action interpreted as time-reversed sensory perception directly reflects the fact that state function reductions occur as sequences to the same boundary of causal diamond (CD) (which itself or rather, quantum superposition of CDs, changes in the process such that either the upper or lower boundaries of all CDs involved are localized at the same light-cone boundary). The first reduction of sequence corresponds to genuine state function reduction and the next induce changes only at the second boundary giving rise to experience flow of time and arrow of time.

2. Also the abstraction and de-abstraction processes in various scales which are essential for neural processing emerge already at the level of quantum jump. The formation of associations is one aspect of abstraction since it combines different manners to experience the same object. Negentropic entanglement of two or more mental images (CDs) gives rise to rules in which superposed n-particle states correspond to instances of the rule or association of n events. Schrödinger cat serves as an example: the superposition of living cat-closed bottle and dead-cat-open bottle gives a quantum representation for the rule that it is not good idea to open the bottle. Cat attending to/quantum entangling with the bottle is conscious about the rule. Tensor product formation generating negentropic entanglement between new mental images and earlier ones generates longer sequences of memory mental images and gives rise to negentropy gain generating experience of understanding, recognition, something which has positive emotional coloring. Quantum superposition of perceptively equivalent zero energy states in given resolution gives rise to averaging. Increasing the abstraction level means poorer resolution so that the insignificant details are not perceived.

3. Various memory representations should be approximately invariant under the sequence of quantum jumps. Negentropic entanglement gives rise to this kind of stabilization. The assumption that self model is a negentropically entangled system which does not change in state function reduction, leads to a problem. If the conscious information about this kind of subself corresponds to change of negentropy in quantum jump, it seems impossible to get this information. Quite generally, if moment of consciousness corresponds to quantum jump and thus *change*, how is it possible to carry conscious information about *quantum state*? Interaction free measurement however allows to circumvent the problem: non-destructive reading of memories and future plans becomes possible in arbitrary good approximation.

   This memory reading mechanism can be formulated for both photons and phonons and these two reading mechanisms could correspond to visual memories as imagination and auditory memories as internal speech. Therefore dark photons decaying to bio-photons could be crucial element of imagination. The notion of bio-phonon could also make sense and even follow as a prediction. The identification of dark photons responsible for the reading of memories with EEG is suggested by the strong correlation of latter with the contents consciousness. This would also suggest a correlation of bio-photon emission with EEG for which there is a considerable evidence. The indications that bio-photons are associated only with the right hemisphere suggests that at least some parts of right hemisphere prefer dark photons and are thus specialized to visual imagination: spatial relationships are the speciality of the right hemisphere. Some parts the of left hemisphere at least might prefer dark photons in IR energy range transforming to ordinary phonons in ear or dark phonons: left hemisphere is indeed the verbal hemisphere specialized to linear linguistic cognition.

4. After the writing of the original version of the chapter it turned out that there are good justifications for the proposal that the energy spectrum of dark photons might be universal and do not depend on the mass of the charged particle. This requires that h_{eff} is proportional to the mass of the charged particle. This conforms with the hypothesis that bio-photons result in the transformation of dark photons to ordinary photons and the hypothesis cyclotron frequencies code serve as kind of passwords characterizing the ion. Dark ions could also affect ordinary matter by inducing molecular transitions in visible and UV ranbge by transforming first to bio-photons.

In the following I shall discuss bio-photons in TGD Universe as decay products of dark photons and propose among other things an explanation for the hyperbolic decay law in terms of quantum coherence and echo-like mechanism guaranteeing replication of memory representations. Applications to biology, neuroscience, and consciousness are discussed and also the possible role of bio-photons for remote mental interactions is considered. Also the phenomenon of Taos hum is discussed as a possible evidence for biophonons.

Dark photons from transitions of dark valence electrons as origin of bio-photons, and their interaction with carcinogens

The possible role of bio-photons in living matter is becoming gradually accepted by biologists and neuroscientists. Bio-photons serve as a diagnostic tool and it seems that their intensity increases in non-healthy organism. I have proposed that bio-photons emerge from what I call dark photons, which are ordinary photons but have non-standard value $h_{eff} = nh_0$ of Planck constant.

In this article the consequences of the hypothesis that dark photons emerging from the transitions of dark valence electrons of any atom possessing lonely unpaired valence electron could give rise to part of bio-photons in they decays to ordinary photons. The hypothesis is developed by considering a TGD based model for a finding, which served as a starting point of the work of Popp: the irradiation of carcinogens with light at wavelength of 380 nm generates radiation with wavelength 218 nm so that the energy of the photon increases in the interaction. Also the findings of Veljkovic about the absorption spectrum of carcinogens have considerably helped in the development of the model.

The outcome is a proposal for dark transitions explaining the findings of Popp and Veljkovic. The spectrum of dark photons also suggests a possible identification of metabolic energy quantum of .5 eV and of the Coulomb energy assignable to the cell membrane potential. The possible contribution to the spectrum of bio-photons is considered, and it is found that spectrum differs from a smooth spectrum since the ionization energies for dark valence electrons depending on the value of h_{eff} as $1/h_{eff}^2$ serve as accumulation points for the spectral lines. Also the possible connections with TGD based models of color vision and of music harmony are briefly discussed.

Part I

GENERAL IDEAS

Chapter 2

Quantum Mind, Magnetic Body, and Biological Body

2.1 Introduction

Quantum biology-rather than only quantum brain- is an essential element of Quantum Mind in TGD Universe. Cells, biomolecules, and even elementary particles are conscious entities and the biological evolution is evolution of consciousness so that it would be very artificial to restrict the discussion to brain, neurons, or microtubules. The basic new physics inspired ideas behind TGD inspired quantum biology have been discussed already in the first article but deserve to be listed.

The article is devoted to some applications of TGD inspired view about Quantum Mind to biology. Magnetic body carrying dark matter and forming an onion-like structure with layers characterized by large values of Planck constant is the key concept. Magnetic body is identified as intentional agent using biological body as sensory receptor and motor instrument. EEG and its fractal variants are identified as a communication and control tool of the magnetic body and a fractal hierarchy of analogs of EEG is predicted. Living system is identified as a kind of Indra's net with biomolecules representing the nodes of the net and magnetic flux tubes connections between then. The reconnection of magnetic flux tubes and phase transitions changing Planck constant and therefore the lengths of the magnetic flux tubes are identified as basic mechanisms behind DNA replication and analogous processes and also behind the phase transitions associated with the gel phase in cell interior. The braiding of magnetic flux makes possible universal memory representation recording the motions of the basic units connected by flux tubes. Braiding also defines topological quantum computer programs updated continually by the flows of the basic units. The model of DNA as topological quantum computer is discussed as an application.

In the following I briefly summarize some applications to quantum biology. I am of course forced to leave details to the books about TGD inspired theory of consciousness and quantum biology at my homepage [K113, K24, K85, K51, K23, K61, K65, K106].

1. A vision about relationship between information processing and metabolism in TGD Universe is represented.

    (a) The already existing ideas include the notion of time mirror mechanism as a ways to realized intentional action, memory recall, and remote metabolism by sending negative energy photons to geometric past where some system able to absorb them exists. The proposal is that the utilization of ATP is also possible in this way: this quantum credit card would make living matter extremely flexible since instantaneous reaction to changing circumstances would become possible. Many-sheeted space-time inspires the idea that the dropping of particles, in particular electrons and protons, to larger space-time sheets liberates metabolic energy. This mechanism would provide universal metabolic currencies and also ATP-ADP might be based on it.

    (b) The new idea is that the presence of ATP at magnetic flux tube is a necessary prerequisite for negentropic entanglement between its ends. ATP could be seen as a molecule of consciousness in this picture and high energy phosphate bond would be replaced with

a state involving negentropic entanglement. There is also a connection with the model of living matter as quantum computer.

(c) A possible modification of second law to take into account negentropic entanglement is discussed. The pessimistic modification states that genuine islands of negentropy can be generated rather than islands in which entropy is very small. The generation of negentropy is however always accompanied by compensating generation of entropy. A possible interpretation is that the eventual reduction of negentropic entanglement in state function reduction generates this entropy at ensemble level.

2. TGD approach to living matter was strongly motivated by the findings about strange behavior of cell membrane and of cellular water, and gel behavior of cytoplasm. These findings are briefly discussed in TGD framework by bringing in magnetic flux tubes as a new element.

3. Water is in key role in living matter and TGD inspired view about water and various anomalies related to the physics of water are also discussed.

The appendix of the book gives a summary about basic concepts of TGD with illustrations. Pdf representation of same files serving as a kind of glossary can be found at `http://tgdtheory.fi/tgdglossary.pdf` [L18].

2.2   Quantum Mind And Magnetic Body

The notion of magnetic/field body (see **Fig.** `http://tgdtheory.fi/appfigures/fluxquant.jpg` or **Fig. ??** in the appendix of this book) is probably the feature of TGD inspired theory of quantum biology which probably creates strongest irritation in standard model physicist. A ridicule as some kind of Mesmerism might be the probable reaction. The notion of magnetic/field body has however gradually gained more and more support and it is now an essential element of TGD based view about living matter. In the following I discuss the basic applications in the hope that the overall coherency of the picture might force some readers to take this notion seriously. The notion of magnetic body leads to a dramatic modification of the views about functions of brain and biological systems in general. I will talk mostly about magnetic body although it is clear that field body has also electric parts (electric flux quanta with cell membrane and various electrets populating living matter) as well as radiative parts realized in terms of "massless extremals" or topological light rays [K79] providing correlates for EEG and its fractal analogs.

2.2.1   Living Matter As Ordinary Matter Controlled By Dark Matter At Magnetic Bodies

The notions of many-sheeted space-time, topological field quantization, and magnetic body were in a key role in the model of living matter as a macroscopic quantum system. It was assumed that space-time sheets are not at thermal equilibrium and that the space-time sheets responsible for the macroscopic quantum coherence are at very low temperature. See the article "Biosystems as macroscopic quantum systems" [L1] and **Figs. ??, ??, ??, ??,** and **??** in the appendix of this book.

1. Libet's findings and the model of memory based on time mirror hypothesis suggests that magnetic body is indeed needed. What is the real function of magnetic body? Is it just a sensory canvas? The previous considerations suggest that it is also the seat of geometric qualia, in particular the pitch of sound should be coded by it. It would be relatively easy to understand magnetic body as a relatively passive sensory perceiver defining sensory map. If one assumes that motor action is like time reversed sensory perception then sensory and motor pathways would be just sensory pathways proceeding in opposite time directions from receptors to the various layers of the magnetic body. Brain would perform the information processing.

Certainly there must exist a region in which the motor and sensory parts of the magnetic body interact. What comes in mind is that these space-time sheets (or actually pairs of space-time sheets) are parallel and generate wormhole contacts between them. This interaction would

be assignable to the region of the magnetic body could receive positive energy signals from associative sensory areas and send negative energy signals to motor motor neurons at the ends of motor pathways wherefrom they would propagate to premotor cortex, supplementary motor cortex and to frontal lobes where the abstract plans about motor actions are generated.

2. The hierarchy of Planck constants and identification of dark matter as phases with non-standard value of Planck constant makes it possible to give up the assumption about low temperatures at flux quanta. Dark matter becomes the key notion in the quantum controller of ordinary matter in living matter. The large value of Planck constant - integer multiple of standard value- scales up quantum lengths since typically they are proportional to $\hbar$ and scales the quantum coherence lengths and times. This also scales the energy $E = hf$ associated with a photon with given frequency. This allows to understand the quantal effects of ELF em fields to vertebrate brain.

3. Large Planck constant means that quantum length scales such as Compton length are scaled up. This makes possible macroscopic quantum coherence and non-locality. Magnetic flux tubes are identified as carriers of dark matter with non-standard value of Planck constant.

4. The ideas about the role of magnetic flux quanta have evolved considerably. It is natural to assume that magnetic flux tubes carry macroscopic quantum phases of dark matter. The phase transitions changing Planck constant reduce or increase the length of the flux tube and could be responsible for the dramatic volume changes of cytoplasm. The reconnections of magnetic flux tubes make possible dynamics for the topology of the web formed by magnetic flux tubes. ATP-ADP process can be associated with this kind of reconnection process. The braiding of magnetic flux tubes makes possible topological quantum computations and DNA and lipid layers of cell membrane form an ideal hardware for topological quantum computer with braiding of flux tubes connecting lipid layers with DNA nucleotides defining the TQC programs. Braiding provides also a universal memory storage mechanism since liquid flow induces braiding of the particle in the flow. Lipid layers of cell membrane are indeed liquid crystals so that their flows update quantum computer programs coded by space-like braiding.

5. Living matter would be ordinary matter controlled by the dark manner at the "magnetic body" of the system and magnetic flux tubes and sheets act as carriers of dark matter. Phase transitions changing the value of Planck constant induce contractions or lengthenings of the flux tubes and would be key mechanism in the volume changing phase transitions in living matter. Reconnection process for the flux tubes is second mechanism and ATP-ADP mechanism would involve basically the reconnection which would in quantum computer inspired picture mean formation of a link to and address in memory. Braiding of flux tubes makes possible topological quantum computation. For details see the chapters

Macroscopic quantum coherence and metabolism as different sides of the same coin (see `http://tinyurl.com/yd7j9f5j`) [K57].

DNA as topological quantum computer (see `http://tinyurl.com/ybyscdpt`) [K5].

Dark Matter Hierarchy and Hierarchy of EEGs (see `http://tinyurl.com/y9y87z84`) [K44].

TGD Based View about Classical Fields in Relation to Consciousness Theory and Quantum Biology (see `http://tinyurl.com/y9exp84r`) [K111].

Quantum model for bio-superconductivity:part I (see `http://tinyurl.com/yahrlysf`) [K89].

Quantum model for bio-superconductivity:part II (see `http://tinyurl.com/y7fbb4hm`) [K90].

Quantum model for nervepulse (see `http://tinyurl.com/y8e5oqkm`) [K92].

2.2.2 Magnetic Body As Intentional Agent And Experiencer

In TGD Universe brain would be basically a builder of symbolic representations assigning a meaning to the sensory input by decomposing sensory field to objects and making possible effective motor control by magnetic body containing dark matter. A concrete model for how magnetic controls biological body and receives information from it is discussed in the model for the nerve pulse [K92] and for the hierarchy of EEGs [K44, K95].

Also magnetic body could have sensory qualia, which should be in a well-defined sense more refined than ordinary sensory qualia [K50]. The quantum number increments associated with cyclotron phase transitions of dark ion cyclotron condensates at magnetic body could relate to the cognitive and possibly also emotional content of sensory input and would indeed have interpretation as higher level sensory qualia. On the other hand, the positive/negative emotional coloring itself might be the core of what it is to be emotion and most naturally relates to the sign of negentropy increment in quantum jump so that it would not be a quale in the sense that visual colors are.

Right brain sings – left brain talks metaphor could characterize this emotional-cognitive (holistic-reductionistic) distinction for higher level qualia and would correspond to coding of sensory input from brain by frequency patterns *resp.* temporal patterns (analogs of phonemes). Fourier analysis indeed transforms local data into holistic data.

These qualia could be seen as somatosensory qualia at the level of magnetic body. One must be however cautious with interpretations. It is not all obvious whether the qualia should be assigned with body alone or magnetic body alone or both. Out of body experiences and various illusions such as train illusion and the disgusting sensation about falling when one is near the edge of cliff could be virtual world experiences resulting from the relative motion of the magnetic body with respect to the biological body: the sensory sensation would correspond to to the interference effects for dark photon radiation between the biological body and magnetic body [K110].

TGD framework fundamental qualia are associated with sensory receptors although also neuronal qualia are possible. The new view about time allows to overcome the arguments suggesting that qualia must be solely at the level of brain (say the pain in phantom limb).

Remote mental interactions between magnetic body and biological body are a key element of this picture. Remote mental interactions in the usual sense of the world would occur between magnetic body and some other, not necessary biological, body. This would include receival of sensory input from and motor control of other than own body. Also inanimate matter (no negentropic entanglement) possesses magnetic bodies (so that also psychokinesis could be based on the same mechanism). Magnetic body for which dissipation is much smaller than for ordinary matter (proportional to $1/\hbar$), could continue its conscious existence after biological death and find another biological body and use it as a tool of sensory perception and intentional action.

2.2.3 Time Mirror Mechanism Can Be Seen As The Basic Mechanism Of Memory, Intentional Action, And Metabolism

It means sending negative energy signal propagating backwards in time and ZEO gives precise meaning for this notion.

1. Memory recall in the case of symbolic memories would correspond to sending of negative energy signal to geometric past. The signal would be reflected as positive energy signal. An alternative possibility is that time-like entanglement is generated. This mechanism would make it un-necessary to store memories again and again. The proposed model for the recent finding that memory code with six bits might make sense suggests that metabolism is necessarily involved. The negative energy quantum absorbed in geometric past transforms ATP to ADP and deletes the conscious memory item but creates it again in the geometric now. This would conform with no-cloning theorem.

2. Sending of negative energy signals to a system serving as energy storage to generate metabolic energy as a recoil makes possible an extremely flexible quantum credit card in living matter. This kind of flexibility is extremely useful in circumstances requiring very rapid reactions.

3. Motor actions could be regarded as realizations of intentions using negative energy signals propagating to the direction of geometric past. This hypothesis would explain the strange finding of Libet that conscious decision in volitional action seems to occur later than the neural activity initiating the motor action. One could argue that the free will aspect of motor actions does not conform with the interpretation as sensory perception in reversed direction of time. On the other hand, also percepts are selected -say in binocular rivalry [J45]. Only single alternative percept need to be realized in a given branch of the multiverse. This makes possible metabolic economy: for instance, the synchronous firing at kHz frequency serving as a correlate for the conscious percept requires a lot of energy since dark photons at kHz

frequency have energies above thermal threshold. Similar selection of percepts could occur also at the level of sensory receptors but quantum statistical determinism would guarantee reliable perception. The passivity of sensory perception and activity of motor activity would reflect the breaking of the arrow of time if this interpretation is correct.

2.2.4 Biosystems As Conscious Holograms

The notion of conscious hologram is TGD based generalization of the idea about brain as a hologram. In nutshell, the notion of conscious hologram follows from the topological field quantization. Classical fields and matter form a Feynman diagram like structure consisting of lines representing matter (say charged particles) and bosons (say photons). The matter lines are replaced by space-time sheets representing matter (elementary particles, atoms, molecules, ...), and virtual bosons are replaced by topological light rays ("massless extremals", MEs). Also magnetic flux tubes appear and together with MEs they serve as correlates for bound state quantum entanglement.

The internal lines of the Feynman diagram are analogous to wave guides and the classical fields and coherent light propagating along these wave guides interfere at the space-time sheets representing the vertices of the Feynman diagram and the "points" of the conscious hologram. The formation of the hologram corresponds to the self-organization induced by the leakage of supra currents to smaller (say atomic) space-time sheets. This leakage is induced by the high frequency MEs propagating along low frequency MEs serving as correlates for quantum entanglement. The 3-D stereovision associated with ordinary hologram is generalized to stereo consciousness resulting, when the mental images associated with different "points" of conscious hologram fuse to single mental image. Central nervous system can be regarded as a conscious hologram of this kind.

Time mirror mechanism (see **Fig. `http://tgdtheory.fi/appfigures/timemirror.jpg` or Fig. ??** in the appendix of this book) is a key element of intentional action. The notion of four-wave interaction generalizes: the interference pattern of oppositely moving reference waves forming an archetypal standing wave (possibly moving as in case of nerve pulse) can be replaced by any synchronously oscillating periodic spatial pattern. Plasma waves for which the frequency does not depend on wave vector are ideal candidates for holograms in the generalized sense. Living matter is full of this kid of holograms: besides plasma oscillations associated with biologically important ions, also Z^0 plasma oscillations associated with atoms and molecules can define holograms. p-Adic length scale hypothesis predicts a hierarchy of plasma frequencies related by powers $2^{3k/4}$ so that even so called "non-living matter" could build this kind of sensory representations based on plasma oscillations.

p-Adic length scale hypothesis and dark matter hierarchy allow to quantify the notion of conscious hologram. The hierarchy of generalized EEGs associated with the dark matter hierarchy allows to propose concrete mechanism of remote mental interactions playing a key role also in the interaction of magnetic bodies with the biological body. Experimental findings related to anomalous pre-cognition support the view that even galactic magnetosphere acts as a conscious entity receiving sensory input from bio-sphere and controlling it.

Bio-photons provide an application of the general theory. Simple mathematical facts about the delayed luminescence induced by an external perturbation combined with the model for a hierarchy of dark EEGs assignable to that of Josephson junctions, lead to a model in which positive and negative energy MEs transversal to DNA strand and representing dark photons generate coherent bio-photons via de-coherence. Rather detailed quantitative models for how MEs and supra current circuits interact and how bio-photons are generated during the gene expression emerge.

Peter Gariaev and his group have discovered a radio wave emission from DNA induced by laser light. The model explaining delayed luminescence covers also this phenomenon: now the decay of dark photons with energies above thermal threshold to radio-wave photons rather than de-coherence would be the mechanism. The findings allow an explanation in terms of a many-sheeted laser action, and a rather detailed view about how bio–system acts as a many-sheeted laser at a wide wave-length range emerges.

William Tiller in Stanford University has carried out impressive experimental work with what he calls intention imprinted electronic devices (IIED), and his results challenge that standard assumption that the intentions of experimenter do not affect the experimental apparatus. The analysis of the work of Tiller in the conceptual framework of TGD leads to the conclusion that

four-wave interaction, which is a basic mechanism to produce phase conjugate waves (negative energy topological light rays), serves also as a basic mechanism of intentional action. This leads to a unified view allowing to see EEG and nerve pulse as a particular realization of four-wave interaction.

2.2.5   High T_c Superconductivity In Living Matter

The TGD inspired model for high T_c super-conductivity as quantum critical phenomenon is developed. The relies on the notions of quantum criticality, dynamical quantized Planck constant requiring a generalization of the 8-D embedding space to a book like structure, and many-sheeted space-time. In particular, the notion of magnetic flux tube as a carrier of supra current of central concept.

The model of super-conductivity

The model for generalized EEG relates very closely to the general model of high T_c superconductivity. This motivates a separate discussion of the vision about bio-super-conductivity in TGD Universe.

1. General mechanisms of bio-superconductivity

The many-sheeted space-time concept provides a very general mechanism of superconductivity based on the "dropping" of charged particles from atomic space-time sheets to larger space-time sheets. The first guess was that larger space-time sheets are very dry, cool and silent so that the necessary conditions for the formation of high T_c macroscopic quantum phases are met.

The possibility of large $\hbar$ quantum coherent phases makes however the assumption about thermal isolation between space-time sheets un-necessary. At larger space-time sheet the interactions of the charged particles with classical em fields generated by various wormhole contacts feeding gauge fluxes to and from the space-time sheet in question give rise to the necessary gap energy. The simplest model for Cooper pair is space-time sheet containing charged particles having attractive Coulombic interaction with the quarks and antiquarks associated with the throats of the wormhole contacts.

Wormhole contacts can be interpreted as Higgs type fields and photon massivation could be understood in terms of a coherent state of charged wormhole contacts. The coherent states of charged wormhole contacts and of Cooper pairs do not imply non-conservation of energy, charge, and fermion number in zero energy ontology.

A crucial element is quantum criticality predicting a new kind of superconductivity explaining the strange features of high T_c super-conductivity. There are two kinds of Cooper pairs, exotic Cooper pairs and counterparts of ordinary BCS type Cooper pairs. Both correspond to a large value of Planck constant. Exotic Cooper pairs are quantum critical meaning that they can decay to ordinary electrons. Below temperature $T_{c_1} > T_c$ only exotic Cooper pairs with spin are present and their finite lifetime implies that super-conductivity is broken to ordinary conductivity satisfying scaling laws characteristic for criticality. At T_c spinless BCS type Cooper pairs become stable and exotic Cooper pairs can decay to them and vice versa. An open question is whether the BCS type Cooper pairs can be present also in the interior of cell.

These two superconducting phases compete in certain narrow interval around critical temperature for which body temperature of endotherms is a good candidate in the case of living matter. Also high T_c superfluidity of bosonic atoms dropped to space-time sheets of electronic Cooper pairs becomes possible besides ionic super conductivity. Even dark neutrino superconductivity can be considered below the weak length scale of scaled down weak bosons.

Magnetic magnetic flux tubes and sheets are especially interesting candidates for supra current carries. In this case the Cooper pairs must have spin one and this is indeed possible for exotic Cooper pairs. The fact that the critical magnetic fields can be very weak or large values of $\hbar$ is in accordance with the idea that various almost topological quantum numbers characterizing induced magnetic fields provide a storage mechanism of bio-information.

This mechanism is extremely general and in principle works for electrons, protons, ions, charged molecules and even exotic neutrinos and an entire zoo of high T_c bio-superconductors, super-fluids and Bose-Einstein condensates is predicted. Of course, there are restrictions due to

the thermal stability it room temperature and it seems that only electron, neutrino, and proton Cooper pairs are possible at room temperature besides Bose-Einstein condensates of all bosonic ions and their exotic counterparts resulting when some nuclear color bonds become charged.

2. Hierarchies of preferred p-adic length scales and values of Planck constant

TGD inspired quantum biology and number theoretical considerations suggest preferred values for $r = \hbar/\hbar_0$. For the most general option the values of $\hbar$ are products and ratios of two integers n_a and n_b. Ruler and compass integers defined by the products of distinct Fermat primes and power of two are number theoretically favored values for these integers because the phases $exp(i2\pi/n_i)$, $i \in \{a, b\}$, in this case are number theoretically very simple and should have emerged first in the number theoretical evolution via algebraic extensions of p-adics and of rationals. p-Adic length scale hypothesis favors powers of two as values of r.

The hypothesis that Mersenne primes $M_k = 2^k - 1$, $k \in \{89, 107, 127\}$, and Gaussian Mersennes $M_{G,k} = (1 + i)k - 1$, $k \in \{113, 151, 157, 163, 167, 239, 241..\}$ (the number theoretical miracle is that all the four p-adic length scales sith $k \in \{151, 157, 163, 167\}$ are in the biologically highly interesting range 10 nm-2.5 μm) define scaled up copies of electro-weak and QCD type physics with ordinary value of $\hbar$ and that these physics are induced by dark variants of corresponding lower level physics leads to a prediction for the preferred values of $r = 2^{k_d}$, $k_d = k_i - k_j$, and the resulting picture finds support from the ensuing models for biological evolution and for EEG [**?**] This hypothesis - to be referred to as Mersenne hypothesis - replaces the earlier rather ad hoc proposal $r = \hbar/\hbar_0 = 2^{11k}$ for the preferred values of Planck constant.

The role of Josephson currents

The general vision is that Josephson currents of various ions generate Josephson photons having dual interpretations as bio-photons and EEG photons. Josephson photons can in principle regenerate the quale in the neurons of the sensory pathway. In the case of motor pathways the function would be different and the transfer of metabolic energy by quantum credit card mechanism using phase conjugate photons is suggested by the observation that basic metabolic quanta 2 eV *resp.* 4 eV are associated with smooth muscle cells *resp.* skeletal muscle cells.

As already found in the previous section, the energies of Josephson photons associated with the biologically important ions are in general in visible or UV range except when resting potential has the value of -40 mV which it has for photoreceptors. In this case also IR photons are present. Also the turning point value of membrane potential is +40 mV so that one expects the emission of IR photons.

Josephson photons could be used to communicate the qualia to the magnetic body.

1. If Josephson currents are present during the entire action potential, the entire range of Josephson photons down to frequencies of order 2 kHz range is emitted for the standard value of $\hbar$. The reason is that lower frequencies corresponds to cycles longer than the duration of the action potential. The continuum of Josephson frequencies during nerve pulse makes it possible to induce cyclotron transitions at the magnetic body of neuron or large structure. This would make possible to communicate information about spatial and temporal behavior of the nerve pulse pattern to the magnetic body and build by quantum entanglement a sensory map.

2. The frequencies below 2 kHz could be communicated as nerve pulse patterns. When the pulse rate is above $f = 28.57$ Hz the sequence of pulses is experienced as a continuous sound with pitch f. f defines the minimum frequency for which nerve pulses could represent the pitch and there remains a 9 Hz long range to be covered by some other communication method.

3. The cyclotron frequencies of quarks and possibly also of electron would make possible a selective reception of the frequencies emitted during nerve pulse. Same applies also to the Josephson frequencies of hair cell (, which does not fire). If the value of Planck constant is large this makes possible to communicate the entire range of audible frequencies to the magnetic body. Frequency would be coded by the magnetic field strength of the flux tube. Two options are available corresponding to the standard ground state for which Z^0 field is

fermion	$f_c(e)/MHz$	$f_c(u)/MHz$	$f_c(d)/MHz$
standard	.564	.094	.019
nearly vacuum extremal	8.996	2.275	.947

Table 2.1: Cyclotron frequencies of quarks and electron in magnetic field $B_{end} = .2$ Gauss for standard vacuum with very small Z^0 field and nearly vacuum extremal.

very weak and to almost vacuum extremals. For the first option one as ordinary cyclotron frequencies. The cyclotron frequency scales for them differ by a factor

$$r(q) = \frac{Q_{eff}(q)}{Q_{em}(q)} = \frac{\epsilon(q)}{2pQ_{em}(q)} + 1 \; per, \;\; \epsilon(u) = -1 \;, \epsilon(d) = 1$$

from the standard one. For $p = .0295$ one obtains $(r(u), r(d), r(e)) = (24.42, 49.85, 15.95)$. The cyclotron frequencies for quarks and electron with masses m(u)=2 MeV, m(d)=5 MeV, and m(e)=.5 MeV are given **Table 6.5** for the two options. If one assumes that B_{end} defines the upper bound for field strength then he standard option would require both d quark and electron. Gor $d$quark with kHz CD the upper bound for cyclotron frequencies would be 20 kHz which corresponds to the upper limit of audible frequencies.

4. Besides cyclotron frequencies also the harmonics of the fundamental frequencies assignable to quark and electron CDs could be used and in case of musical sounds this looks a highly attractive option. In this case it is now however possible to select single harmonics as in the case of cyclotron transitions so that only the rate of nerve pulses can communicate single frequency. Lorentz transform sub-CD scales up the frequency scale from the secondary p-adic time scale coming as octave of 10 Hz frequency. Also the scaling of $\hbar$ scales this frequency scale.

4. What are the roles of Josephson and cyclotron photons?

The dual interpretation of Josephson radiation in terms of bio-photons and EEG photons seems to be very natural and also the role of Josephson radiation seems now relatively clear. The role of cyclotron radiation and its interaction with Josephson radiation are not so well understood.

1. At least cell membrane defines a Josephson junction (actually a collection of them idealizable as single junctions). DNA double strand could define a series of Josephson junctions possibly assignable with hydrogen bonds. This however requires that the strands carry some non-standard charge densities and currents- I do not know whether this possibility is excluded experimentally. Quarks and antiquarks assignable to the nucleotide and its conjugate have opposite charges at the two sheets of the wormhole flux tube connective nucleotide to a lipid. Hence one could consider the possibility that a connection generated between them by reconnection mechanism could create Josephson junction.

2. The model for the photoreceptors leads to the identification of bio-photons as Josephson radiation and suggests that Josephson radiation propagates along flux tubes assignable to the cell membranes along sensory pathways up to sensory cortex and from there to motor cortex and back to the muscles and regenerates induced neuronal sensory experiences.

3. Josephson radiation could be used quite generally to communicate sensory data to/along the magnetic body: this would occur in the case of cell membrane magnetic body at least. The different resting voltages for various kinds of cells would select specific Josephson frequencies as communication channels.

4. If motor action indeed involves negative energy signals backwards in geometric time as Libet's findings suggest, then motor action would be very much like sensory perception in time reversed direction. The membrane resting potentials are different for various types of neurons

and cells so that one could speak about pathways characterized by Josephson frequencies determined by the membrane potential. Each ion would have its own Josephson frequency characteristizing the sensory or motor pathway.

The basic questions concern the function of cyclotron radiation and whether Josephson radiation induces resonantly cyclotron radiation or vice versa.

1. Cyclotron radiation would be naturally associated with the flux sheets and flux tubes. The simplest hypothesis is that at least the magnetic field $B_{end} = .2$ Gauss can be assigned with the some magnetic flux quanta at least. The model for hearing suggests that B_{end} is in this case quantized so that cyclotron frequencies provide a magnetic representation for audible frequencies. Flux quantization does not pose any conditions on the magnetic field strength if the above discussed general flux quantization condition involving charged currents at the boundary of the flux quantum are assumed. If these currents are not present, $1/\hbar$ scaling of B_{end} for flux tubes follows.

2. The assumption that cyclotron radiation is associated with the motor control via genome is not consistent with the vision that motor action is time reversed sensory perception. It would also create the unpleasant question about information processing of the magnetic body performed between the receival of sensory data and motor action.

3. The notion of magnetic sensory canvas suggests a different picture. Josephson radiation induces resonant cyclotron transitions at the magnetic body and induces entanglement of the mental images in brain with the points of the magnetic body and in this manner creates sensory maps giving a third person perspective about the biological body. There would be two kind of sensory maps. Those assignable to the external world and those assignable to the body itself. The Josephson radiation would propagate along the flux tubes to the magnetic body.

4. There could be also flux tube connections to the outer magnetosphere of Earth. It would seem that the reconnections could be flux tubes traversing through inner magnetosphere to poles and from there to the outer magnetosphere. These could correspond to rather low cyclotron frequencies. Especially interesting structure in this respect is the magnetic flux sheet at the Equator.

2.2.6   Possible Roles Of The Magnetic Body In Living Matter

An attractive working hypothesis is that dark matter and negentropic entanglement can be assigned to the magnetic bodies. For instance, the dark elementary particles at the ends of the magnetic flux tubes connecting (say) biomolecules could be entangled negentropically. Negentropic entanglement, which is not identifiable as ordinary bound state entanglement, can be applied to explain the stability of high energy phosphate bond in ADP and ATP and of DNA polymers, which are highly charged and thus expected to be unstable [K47, K48]. This also allows to interpret metabolic energy transfer as a transfer of negentropic entanglement at the deeper level.

The anatomy of magnetic body

Consider first the anatomy of the magnetic body.

1. Magnetic body has a fractal onion like structure with decreasing magnetic field strengths and the highest layers can have astrophysical sizes. Cyclotron wave length gives an estimate for the size of particular layer of magnetic body. $B = .2$ Gauss is the field strength associated with a particular layer of the magnetic body assignable to vertebrates and EEG. This value is not the same as the nominal value of the Earth's magnetic field equal to.5 Gauss and follows from the TGD based explanation of the quantal effects of ELF em fields on vertebrate brain known for decades [J28]. It is quite possible that the flux quanta of the magnetic body correspond to those of wormhole magnetic field and thus consist of two parallel flux quanta which have opposite time orientation. This is true for flux tubes assigned to DNA in the model of DNA as a topological quantum computer [K5, K119].

2. The layers of the magnetic body are characterized by the values of Planck constant and the matter at the flux quanta can be interpreted as macroscopically quantum coherent dark matter. This picture makes sense only if one accepts the generalization of the notion of embedding space [K43].

3. In the case of wormhole magnetic fields it is natural to assign a definite temporal duration to the flux quanta and the time scales defined by EEG frequencies are natural. Encouragingly, the inherent time scale.1 seconds assignable to electron as a duration of zero energy space-time sheet in zero energy ontology having positive and negative energy electron at its ends would correspond to 10 Hz cyclotron frequency for ordinary value of Planck constant. For larger values of Planck constants the time scale scales as $\hbar$. Quite generally, a connection between p-adic time scales of EEG and those of electron and lightest quarks is highly suggestive since light quarks play key role in the model of DNA as topological quantum computer.

4. TGD predicts also a fractal hierarchy of scaled variants of electro-weak and color physics so that ZXG, QXG, and GXG corresponding to Z^0 boson, W boson, and gluons appearing effectively as massless dark particles below some biologically relevant length scale suggest themselves. In this phase quarks and gluons are unconfined and electroweak symmetries are unbroken so that gluons, weak bosons, quarks and even neutrinos might be relevant to the understanding of living matter. In particular, long ranged entanglement in charge and color degrees of freedom becomes possible. For instance, TGD based model of atomic nucleus as nuclear string suggests that biologically important fermionic could be actually chemically equivalent bosons and form cyclotron Bose-Einstein condensates.

This picture would mean that dark matter -usually believed to interact extremely weakly with the ordinary matter- would become a key player in biology. The failure to observe dark matter would be the completely wrong view about its nature. In TGD framework dark matter would make itself visible both via classical em fields and via the phase transitions transforming dark photons to ordinary ones. For instance, bunches of EEG photons and bio-photons could be interpreted as decay products dark photons [K44].

What magnetic body looks like?

What magnetic body looks like has been a question that I have intentionally avoided as a question making sense only when more general questions have been answered. This question seems how unavoidable now. Some of the related questions are following. The magnetic flux lines along various parts of magnetic body must close: how does this happen? Magnetic body must have parts of size at least that defined by EEG wavelengths: how do these parts form closed structures? How the magnetic bodies assignable to biomolecules relate to the Earth sized parts of the magnetic body? How the personal magnetic body relates to the magnetic body of Earth?

1. The vision about genome as the brain of cell would suggest that active and passive DNA strands are analogous to motor and sensor areas of brain. This would suggests that sensory data should be communicated from the cell membrane along the passive DNA strand. The simplest hypotesis is that there is a pair of flux sheet going through the DNA strands. The flux sheet through the passive strand would be specialized to communicate sensory information to the magnetic body and the flux sheet through the active strand would generate motor action as DNA expression with transcription of RNA defining only one particular aspect of gene expression. Topological quantum computation assignable to introns and also electromagnetic gene expression would be possible.

2. The model for sensory receptor in terms of Josephson radiation suggests however that flux tubes assignable to axonal membranes carry Josephson radiation. Maybe the flux tube structures assigned to DNA define the magnetic analog of motor areas and flux tubes assigned with the axons that of sensory areas.

3. A complex structure of flux tubes and sheets is suggestive at the cellular level. The flux tubes assignable to the axons would be parallel to the sensory and motor pathways. Also microtubules would be accompanied by magnetic flux tubes. DNA as topological quantum

computer model assumes and the proposed model of sensory perception and cell membrane level suggests transversal flux tubes between lipids and nucleotides. The general vision about DNA as brain of cell suggest flux sheets through DNA strands.

During sensory perception of cell and nerve pulse the wormhole flux tube connecting the passive DNA strand of the first cell to the inner lipid layer would recombine with the flux tube connecting outer lipid layer to some other cell to form single flux tube connecting two cells. In the case of sensory organs these other cells would be naturally other sensory receptors. This would give rise to a dynamical network of flux tubes and sheets and axonal sequences of genomes would be like lines of text at the page of book. This structure could have a fractal generalization and would give rise to an integration of genome to super-genome at the level of organelles, organs and organism and even hypergenome at the level of population. This would make possible a coherent gene expression.

4. This vision gives some idea about magnetic body in the scale of cell but does not say much about it in longer scales. The CDs of electrons and quarks could provide insights about the size scale for the most relevant parts of the magnetic body. Certainly the flux tubes should close even when they have the length scale defined by the size of Earth.

Additional ideas about the structure follow follow if one assumes that magnetic body acts a sensory canvas and that motor action can be regarded as time reversed sensory perception.

1. If the external world is represented at part of the magnetic body which is stationary, the rotation of head or body would not affect the sensory representation. This part of the magnetic body would be obviously analogous to the outer magnetosphere, which does not rotate with Earth.

2. The part of the magnetic body at which the sensory data about body (posture, head orientations and position, positions of body parts) is represented, should be fixed to body and change its orientation with it so that bodily motions would be represented as motions of the magnetic , which would be therefore analogous to the inner magnetosphere of rotating Earth.

3. The outer part of the personal magnetic body is fixed to the inner magnetosphere, which defines the reference frame. The outer part might be even identifiable as the inner magnetosphere receiving sensory input from the biosphere. This magnetic super-organism would have various life forms as its sensory receptors and muscle neurons. This would give quantitative ideas about cyclotron frequencies involved. The wavelengths assignable to the frequencies above 10 Hz would correspond to the size scale of the inner magnetosphere and those below to the outer magnetosphere. During sleep only the EEG communications with outer magnetic body would remain intact.

4. Flux quantization for large value of $\hbar$ poses an additional constraint on the model.

   (a) If Josephson photons are transformed to a bunch of ordinary small $\hbar$ photons magnetic flux tubes can correspond to the ordinary value of Planck constant. If one assumes the quantization of the magnetic flux in the form

   $$\int BdA = n\hbar$$

   used in super-conductivity, the radius of the flux tube must increase as $\sqrt{\hbar}$ and if the Josephson frequency is reduced to the sound frequency, the value of $\hbar$ codes for the sound frequency. This leads to problems since the transversal thickness of flux tubes becomes too large. This does not however mean that the condition might not make sense: for instance, in the case of flux sheets going through DNA strands the condition might apply.

   (b) The quantization of magnetic flux could be replaced by a more general condition

   $$\oint (p - ZeA)dl = n\hbar \ , \tag{2.2.1}$$

where p represents momentum of particle of super-conducting phase at the boundary of flux tube. In this case also $n = 0$ is possible and poses no conditions on the thickness of the flux tube as a function of $\hbar$. This option looks reasonable since the charged particles at the boundary of flux tube would act as sources of the magnetic field.

(c) Together with the Maxwell's equation giving $B = ZeNv$ in the case that there is only one kind of charge carrier this gives the expression

$$N \;\; = \;\; \frac{2m}{RZ^2e^2} \tag{2.2.2}$$

for the surface density N of charge carrier with charge Z. R denotes the radius of the flux tube. If several charge carriers are present one has $B = \sum_k N_k Z_k e v_k$, and the condition generalizes to

$$N_i \;\; = \;\; \frac{2m_i v_i}{RZ_i \sum_k Z_k v_k e^2} \;\; . \tag{2.2.3}$$

It seems that this condition is the most realistic one for the large $\hbar$ flux sheets at which Josephson radiation induces cyclotron transitions.

Some functions of the magnetic body

The list of possible functions of the magnetic body is already now rather impressive.

1. Magnetic body controls biological body and receives sensory data from it. Together with zero energy ontology and new view about time explains Libet's strange findings about time lapses of consciousness [J52] in terms of time taken for the sensory signals from biological body to propagate to the appropriate layer of the magnetic body [K44]. EEG, or actually fractal hierarchy of EXGs assignable to various body parts makes possible communications to and control by the various layers of the magnetic body. WXG could induce charge density gradients by the exchange of W boson. Also the gluonic counterparts of EXG: s -QXG- are possible.

2. The flux sheets of the magnetic body traverse through DNA strands. The hierarchy of Planck constants and quantization of magnetic flux predicts that the flux sheets can have arbitrarily large width [K52]. This leads to the idea that there is hierarchy of genomes corresponding to ordinary genome, supergenome consisting of genomes of several cell nuclei arranged along flux sheet like lines of text, and hypergenomes involving genomes of several organisms arranged in a similar manner. The prediction is coherent gene expression at the level of organ, and even of population.

   For instance, one could see the observed correlations between EEGs of two improvising musicians [J54], the findings of Germine [J102] and also those of Persinger and colleagues about macro-entanglement [J109] as an experimental support for both macroscopic entanglement between brain and for the crucial role of magnetic body as a space-time correlate for this entanglement. In this picture the great leaps in evolution, in particular, the emergence of EEG, could be seen as the emergence of a new larger layer of magnetic body characterized by a larger value of Planck constant. For instance, this would allow to understand why the quantal effects of ELF em fields [J28] requiring so large a value of Planck constant that cyclotron energies are above thermal energy at body temperature are observed for vertebrates only.

3. Magnetic body makes possible information processing in a way highly analogous to topological quantum computation [K5]. The model of DNA as topological quantum computer [K5] assumes that flux tubes of wormhole magnetic field connect DNA nucleotides with the lipids of the lipid layer of nuclear or cell membrane. The flux tubes would continue through the membrane and split during topological quantum computation. The time-like braiding of flux tubes makes possible topological quantum computation via time-like braiding and the induced space-like braiding makes possible the representation of memories. The model allows

general vision about the deeper meaning of the structure of cell and makes testable predictions about DNA. A good metaphor is dancers with feet connected to the walls of the dancing hall by threads. The dance representing quantum computation is coded to the braiding of the threads.

One prediction is the coloring of braid strands realized by an association of quark or antiquark to nucleotide so that scaled up dark copy of QCD in cellular length scale would be involved. Color and spin of quarks and antiquarks would thus correspond to the quantum numbers assignable to braid ends. Color isospin could replace ordinary spin as a representation of qubit and quarks would naturally give rise to qutrit, with third quark would have interpretation as unspecified truth value. Fractionization of these quantum numbers takes place which increases the number of degrees of freedom.

This prediction would relate closely to the discovery of topologist Barbara Shipman [A6] that the model for the honeybee dance suggests that quarks are in some manner involved with cognition -something totally unimaginable unless one accepts the possibility of fractal hierarchies of electroweak and hadronic physics. Also microtubules associated with axons connected to a space-time sheet outside axonal membrane via lipids could be involved with topological quantum computation and actually define an analog of a higher level programming language.

4. The strange findings about the behavior of cell membrane are summarized in [I91] and discussed in TGD framework in [K92]. Mention only the finding that metabolic deprivation does not lead to the death of cell, the discovery that ionic currents through the cell membrane are quantal, and that these currents are essentially similar than those through an artificial membrane, suggest that the ionic currents are dark ionic Josephson currents along magnetic flux tubes. A high percent of biological ions would be dark and ionic channels and pumps would be responsible only for the control of the flow of ordinary ions through cell membrane.

   A further important finding is that the water in the cell interior in gel phase is ordered and nearer to ice that liquid [I91]. This explains nicely the stability of DNA and various biopolymers as being due to the fact that depolymetrization by hydration is not possible in this phase. One could envisage the resting state of cell as a cellular winter during which proteins are folded or frozen to unfolded configurations by strong hydrogen bonds. External perturbation feeds energy to the system and induces periods during which the ice is frozen and proteins wake up and begin to unfold or fold and form aggretates as a response to the perturbation and return to the ground state after the energy of the signal is dissipated.

5. These findings together with the discovery that also nerve pulse seems to involve only low dissipation lead to a model of nerve pulse in which dark ionic currents automatically return back as Josephson currents without any need for pumping. This does not exclude the possibility that ionic channels might be involved with the generation of nerve pulse. In TGD inspired model [K92] nerve pulse would result as a perturbation of $f \simeq 1$ kHz frequency soliton sequence mathematically equivalent to a situation in which a sequence of gravitational penduli rotates with constant phase difference between neighbors except for one pendulum which oscillates and oscillation moves along the sequence with the same velocity as the kHz wave. The oscillation would be induced by a "kick" for which one can imagine several mechanisms. Nerve pulse would be like dissonance in background harmony. This view conforms with the general vision that any equilibium in living matter is homeostasis rather than analog of equilibrium in mechanical system.

   The model explains some features of nerve pulse not explained by Hodkin-Huxley model. These include the mechanical changes associated with axon during nerve pulse, the outwards force generated by nerve pulse with a correct prediction for its order of magnitude, the adiabatic character of nerve pulse, and the small rise of temperature of membrane during pulse followed by a reduction slightly below the original temperature.

   The model predicts that the time taken to travel along any axon is a multiple of time dictated by the resting potential so that synchronization is an automatic prediction and would have nothing to do with transmitters. Not only kHz waves but also a fractal hierarchy of EEG (and EXG) waves are induced as Josephson radiation by voltage waves along axons and

microtubules and by standing waves assignable to neuronal (cell) soma. The value of Planck constant involved with flux tubes determines the frequency scale of EXG so that a fractal hierarchy results.

The model forces to challenge the existing interpretation of nerve pulse patterns and the function of neural transmitters. Neural transmitters need not represent actual/only) signal but could be more analogous to links in quantum web. The transmitter would code the address of the receiver, which could be a gene inside neuronal nucleus. Nerve pulses would build a connection line between sender and receiver of nerve pulse along which actual signals would propagate. Also quantum entanglement between receiver and sender can be considered.

6. Acupuncture points, meridians, and Chi are key notions of Eastern medicine and find a natural identification in terms of magnetic body lacking from the western medicine. Also a connection with well established notions of DC currents and potentials discovered by Becker and with TGD based view about universal metabolic currencies as differences of zero point energies for pairs of space-time sheets with different p-adic length scale emerges [K57]. The spectrum for increments of zero point kinetic energies represents lines which cannot be explained in terms of molecule physics and the empirical evidence for them is discussed in [K17]

Chi would correspond to these fundamental metabolic energy quanta to which ordinary chemically stored metabolic energy would be transformed. The identification nearest in spirit to the original intuition would be in terms of negentropic entanglement. Meridians would most naturally correspond to flux tubes with large $\hbar$ along which dark supra currents flow without dissipation and transfer the metabolic energy between distant cells. Acupuncture points would correspond to points between which metabolic energy is transferred and their high conductivity and semiconductor like behavior would conform with the interpretation in terms of metabolic energy storages.

The energy gained in the potential difference between the points would help to kick the charge carrier to a smaller space-time sheet. It is possible that the main contribution to the of charge at magnetic flux tube is magnetic energy and slightly below the metabolic energy quantum and that the voltage difference gives only the lacking small energy increment making the transfer possible. Also direct kicking of charge carriers to smaller space-time sheets by photons is possible and the observed action spectrum for IR and red photons corresponds to the predicted increments of zero point kinetic energies.

7. The notion of magnetic body implies the notion of magnetic motor actions. Magnetic flux tubes and their motor actions could play key role in bio-catalysis and explain the magic ability of biomolecules to find each other. The model of DNA as topological quantum computer [K5] suggest that not only DNA and its conjugate but also some amino-acid sequences acting as catalysts could be connected to DNA and other amino-acids sequences or more general biomolecules by flux tubes acting as colored braid strands. The shortening of the flux tubes in a phase transition reducing the value of Planck constant would make possible extremely selective mechanisms of catalysis allowing precisely defined locations of reacting molecules to attach to each other. With recently discovered mechanism for programming sequences of biochemical reactions (based on idea that each step in the reaction sequence means key allowing to open the door to the room containing the next key) [I98] this would make possible to understand the miraculous looking feats of bio-catalysis. Second key mechanism would be the re-connection of the magnetic flux tubes changing the topology of the Indra's net formed by magnetic flux tubes having biomolecules at their nodes.

8. Water memory is one of the highly disputed notions and motivated by the claimed effects of homeopathy. Water memory for which the work of the group led by HIV Nobelist L. Montagnier [I65] gives support would be naturally based on the coding of the biologically relevant properties of molecules to the cyclotron frequencies of its magnetic body. Water memory could rely on the copies of this magnetic body.

Quite surprisingly, the finding of the group suggest also that genetic code might have hitherto unknown realization. TGD indeed predicts several realizations, for instance those based on electromagnetic field patterns [K52]. The model of watermemory [K53] in turn led to a theoretical surprise [K119]. One could understand DNA, RNA, tRNA, and amino-acids in

terms of states of dark nucleons constructed from three quarks and that vertebrate genetic code follows as a prediction in the sense that the numbers of counterparts of DNA codons coding for given amino-adic are predicted correctly [L3]. Prebiotic evolution as a process leading to a chemical realization of fundamental codes and counterparts of biomolecules existing already at the level of elementary particle physics together with the reduction of metabolic currencies to increments of zero point energies would solve two egg or hen problems of theoretical biology.

There is no reason to assume that dark genes would not be still there and in close interaction with ordinary genes and in principle they could make possible controlled evolution analogous to industrial R&D process based on the construction of new genetic variants at the virtual world level of dark genes and the transcriptions to ordinary genes so that the new options could be tested under real life situations.

9. Although not directly related to the notion of magnetic body, the ability to construct "stories", temporally scaled down or possible also scaled up representations about the dynamical processes of external world, deserves to be mentioned. This ability might be actually one of the key aspects of intelligence [K5]. There is direct empirical evidence for this activity in hippocampus [J126]. The phase transitions reducing or increasing the value of Planck constant would indeed allow to achieve this by scaling the time duration of the zero energy space-time sheets providing cognitive representations.

How genetic code could be represented in terms of frequencies? The TGD based model of music harmony [L19] [K91] (see `http://tinyurl.com/zg3aaj7`) relies on the idea that 12-note scale is representable as a closed non-self-intersecting curve (Hamilton's cycle) at icosahedron having 12 vertices. The harmony assignable to a given Hamilton's cycle is characterized in terms of 3-chords assignable to the 20 faces (triangles) of the icosahedron once the 12-note scale is represented as a particular Hamilton's cycle.

Remarkably, the number of amino-acids is also 20! One indeed ends up with a model in which 20+20+20=60 DNA codons are represented by 3-chords for a triplet of harmonies defined by Hamilton's cycles predicting correctly the numbers of DNAs coding for a given amino-acid for vertebrate code. One must however assume that also tetrahedral harmony is present to get 64 DNA codons rather than only 60. TActually two variants of the code are predicted and altogether one obtains the standard 20 amino-acids plus two additional ones identified as Pyl and Sec known to be realized in living matter.

In music realization DNA codons can be represented as 3 dark photons or phonons with appropriate frequency ratios. This representation could explain the findings of Montagnier and Gariaev. There is also a connection with TGD inspired theory of consciousness. Music both expresses and induces emotions. The proposal is that the representation of DNA codons in terms of triplets of sounds or dark photons defines molecular level representation of emotions. There is large number of different harmonies and they could represent different moods.

Dark water and water memory: genetic code realized at elementary particle level?

The assumption was that water -possibly in liquid crystal like state- provides representations of molecules and in this manner makes possible water memory, frequency imprinting.

The hierarchy of Planck constants has brought additional details to this picture.

There is experimental evidence for what might be called dark hydrogen associated with water. The chemical formula of water is $H_{1.5}O$ in atto-second time scale and this could be explained if $1/4$ of hydrogens are in dark phase. The dark portion of water could explain the numerous anomalies of water as a condensed matter phase. Water memory can be assigned with the magnetic bodies of the water molecule clusters and braiding would again be an excellent candidate for memory representations. Cyclotron Bose-Einstein condensate provide representation of water memory as temporal radiation patterns. They could be generated in the liquid flows inducing braiding. An interesting idea is that archetypal liquid flows are selected as asymptotic self-organization patterns and are accompanied by characeristic radiation patterns making possible "naming" of these patterns and symbolic dynamics.

A simple model for dark nucleons, their states of dark predicts that the dark nucleon states are in one-one correspondence with DNA, RNA, tRNA, and amino-acids in a natural manner

and that vertebrate genetic code emerges in a natural manner from the model. This suggests that genetic code is realized at nucleon level for the dark component of water and chemical realization is only secondary realization. This leads to a dramatic modification of views about the evolution of genome. It would not be anymore random choice followed by selection but much more like R&D in industry. The assumption that there is transcription of dark variants of the basic biomolecules to their chemical counterparts would make the new view possible. The basic mechanism of homeopathy would be basic mechanism of evolution allowing to modify genome as a response to environmental factors and also transfer the modifications to offspring.

The identification of bio-photons as ordinary photons resulting in the phase transition reducing the Planck constant assignable to dark photons is very natural and revises the model suggested in the article "A model for bio-photons" (see `http://tinyurl.com/ycr4hvq2`). Dark photons propagating along magnetic flux tube would play a key role also in the physics of biological body and brain and would provide an additional very fast communication channel besides nerve pulse transmission and various biochemical signalling mechanisms. This leads to a proposal for a model of cell membrane.

Direct experimental evidence for the notion of magnetic body carrying dark matter

The list of nice things made possible by the magnetic body is impressive and one can ask whether there is any experimental support for this notion. The evidence from water memory has been already mentioned. An explanation for the impressive list of anomalies of water [D58] discussed in [K45] provide one possible manner to justify the notion. For instance, it is known that in attosecond time scales water behaves as $H_{1.5}O$ [D55, D68, D36] as if part of hydrogen atoms would be dark.

The findings of Peter Gariaev and collaborators give evidence for the representation of DNA sequences based on the coding of nucleotide to a rotation angle of the polarization direction as photon travels through the flux tube and for the decoding of this representation to gene activation [I55], for the transformation of laser light to light at various radio-wave frequencies having interpretation in terms of phase transitions increasing $\hbar$ [I8], and even for the possibility to photograph magnetic flux tubes containing dark matter by using ordinary light in UV-IR range scattered from DNA [I95].

Fractal hierarchy of magnetic flux sheets and the hierarchy of genomes

The notion of magnetic body is central in the TGD inspired theory of living matter. Every system possesses magnetic body and there are strong reasons to believe that the magnetic body associated with human body is of order Earth size and that there could be an entire hierarchy of these bodies with even much larger sizes. Therefore the question arises what one can assume about these magnetic bodies. The quantization of magnetic flux suggests an answer to this question.

1. The quantization condition for magnetic flux reads in the most general form as $\oint (p - eA) \cdot dl = n\hbar$. If supra currents flowing at the boundaries of the flux tube are absent one obtains $e \int B \cdot dS = n\hbar$, which requires that the scaling of the Planck constant scales up the flux tube thickness by r^2 and scaling of B by $1/r$. If one assumes that the radii of flux tubes do not depend on the value of r, magnetic flux is compensated by the contribution of the supra current flowing around the flux tube: $\oint (p - eA) \cdot dl = 0$. The supra currents would be present inside living organism but in the faraway region where flux quanta from organism fuse together, the quantization conditions $e \int B \cdot dS = n\hbar$ would be satisfied.

2. From the point of view of EEG especially interesting are the flux sheets which have thickness $L(151) = 10$ nm (the thickness of cell membrane) carrying magnetic field having strength of endogenous magnetic field. In absence of supra currents these flux sheets have very large total transversal length proportional to r^2. The condition that the values of cyclotron energies are above thermal energy implies that the value of r is of order 2^{k_d}, $k_d = 44$. Strongly folded flux sheets of this thickness might be associated with living matter and connect their DNAs to single coherent structure. One can of course assume the presence of supra currents but outside the organism the flux sheet should fuse to form very long flux sheets.

3. Suppose that the magnetic flux flows in head to tail direction so that the magnetic flux arrives to the human body through a layer of cortical neurons. Assume that the flux sheets traverse through the uppermost layer of neurons and also lower layers and that DNA of each neuronal nuclei define a transversal sections organized along flux sheet like text lines of a book page. The total length of DNA in single human cell is about one meter. It seems that single organism cannot provide the needed total length of DNA if DNA dominates the contribution. This if of course not at all necessarily since supra currents are possible and outside the organism the flux sheets can fuse together. This implies however correlations between genomes of different cells and even different organisms.

These observations inspire the notion of super- and hyper genes. As a matter fact, entire hierarchy of genomes is predicted. Super genes consist of genes in different cell nuclei arranged to threads along magnetic flux sheets like text lines on the page of book whereas hyper genes traverse through genomes of different organisms. Super and hyper genes provide an enormous representative capacity and together with the dark matter hierarchy allows to resolve the paradox created by the observation that human genome does not differ appreciably in size from that of wheat.

Genetic code and dark nucleon states

New realization of the genetic code in terms of dark proton sequences identified as dark nucleons was discovered [L3, K53].

1. The states of dark proton are in natural one-one correspondence with DNA, RNA, tRNA, and amino-acids and vertebrate genetic code is realized in a natural manner. Dark nucleons realized DNA codons as entangled quark triplets. The effective chemical formula $H_{1.5}O$ for water in atto-second time scale supports this view [K43]. How the notion of dark nucleon relates to negentropic entanglement of electrons? Could dark electron pairs and dark nucleons correspond to the same value of Planck constant? Could both dark protons and dark electrons play a key role in metabolism.

2. The simplest guess is that DNA strands are accompanied by dark nuclei with one dark proton per DNA nucleotide. The resulting positive charged would stabilize the system by partially neutralizing the negative charge density due to the phosphorylation (2 negative charges per nucleotide). Dark proton sequences could be associated also with other important bio-polymers. If the spins of the dark protons are parallel the dipole magnetic fields give rise to flux tubes connecting the protons and one can assign to the large $\hbar$ protons a macroscopically quantum coherent phase.

3. The natural guess would be that dark nucleus realization of the genetic code induces the biological realization as evolution assigns to dark nucleon sequences DNA, RNA, and amino-acid sequences with 1-1 correlation between dark nucleon state and basic unit of the sequence. The dark realization of genetic code suggest a totally new view about biological evolution as a process, which is analogous to R&D in high tech industry rather than being completely random [K53]. The candidates for new genes could be tested at dark matter level and in the case that they work they would be transcribed to their chemical equivalents.

Years after writing this I decided to work out the model for dark DNA again and found that codons could be represented instead of 3-dark quarks also by 3 dark nucleons [L34] (see `http://tinyurl.com/jgfjlbe`). Effectively one only replaces u and d quarks with proton and neutron. This option is more promising that the original option.

2.2.7 How To Build A Quantum Computer From Magnetic Flux Tubes

Magnetic flux tubes play a key role in TGD inspired model of quantum biology. Could the networks of magnetic flux tubes containing dark particles with large $\hbar$ in macroscopic quantum states and carrying beams of dark photons define analogs of electric circuits? This would be rather cheap technology since no metal would be needed for wires. Dark photon beams would propagate along

the flux tubes representing the analogs of optical cables and make possible communications with maximal signal velocity.

I have actually made much more radical proposal in TGD inspired quantum biology. According to this proposal, flux tube connections are dynamical and can be changed by reconnection of two magnetic flux tubes. The signal pathways $A \to C$ and $B \to D$ would be transformed to signal pathways to $A \to D$ and $B \to C$ by reconnection. Reconnection actually represents a basic stringy vertex. The contraction of magnetic flux tubes by a phase transition changing Planck constant could be fundamental in bio-catalysis since it would allow distant molecules connected by flux tubes to find each other in the molecular crowd.

DNA as a topological quantum computer is the idea that I have been developing for 5 years or so. I have concentrated on the new physics realization of braids and devoted not much thought to how the quantum computer problems might run in this framework. I was surprised to realize how little I know about what happens in even ordinary computation. Instead of going immediately to Wikipedia I take the risk of publicly making myself fool and try to use my own brain.

What can one learn from ordinary computer programs

One could begin with the question what happens in classical computation. How the program is realized and how it runs? The notion of Turing machine (see `http://tinyurl.com/7c4kl`) represents an extreme abstraction mentioning nothing about the technical side and does not help much in attempts to answer these questions. Turing paradigm also assumes that program is a temporal sequence of operations. These operations could however correspond to a linear spatial sequences and inputs and outputs in this case would correspond to boundary values at the ends of the linear structure. This requires that the dynamics is such that evolution in spatial direction is analogous to a deterministic time evolution. In this case it is much easier to imagine biological realizations of quantum computer programs in TGD inspired bio-world.

To develop concrete ideas, one can start from the picture provided by ordinary computer program.

1. Programs consist of temporal/spatial sequences of commands and commands represent basic functions from which one can build more complex functions by the composition of functions having some numbers of input and output arguments. The eventual output variable can be expressed by printing of a piece of text or as an image in the computer screen. Each step in the program corresponds to a composition of functions: $f_{n+1} = g_{n+1} \circ f_n$. There is some minimal set of primitive/prime functions from which one builds up more complex functions by composition.

2. How this is realized at the level of hardware? One can assume that the basic functions are at some fixed places in the computer memory having addresses given by integers represented as bit sequences. This address represents the command - a name of the function. The names for input variables and output variables are bit sequences giving the addresses of the places containing the values of these variables. Program is a sequence of commands represented as bit sequences giving the address of the function to be computed at a given step and the addresses of inputs and outputs. As the processing unit reads the command, it generates/activates connections from the addresses of inputs to the address representing the function and from this address to the addresses of outputs.

   Essentially the challenge is to reconnect, build/activate connections. An interesting question is whether learning identified as strengthening of synaptic connections (see `http://tinyurl.com/cn7724o`) [J17] is one particular example of this process.

3. How the sequence of bits representing command address is realized? As the processing unit reads the address of command it should automatically create/activate a connection from this address to the command address. The connections from the processing unit to the addresses could exist physically as wirings.

4. It is not necessary that program is dynamical so that the inputs and outputs would be initial and final values of variables. Inputs and outputs could also correspond to values of variables at the ends of a linear structure. In topological quantum computation space-like

entanglement would represent superposition of input-output pairs characterizing a function as a rule with instances represented as instances appearing in the superposition.

If this picture is roughly correct, re-connection would be the basic process. Reconnection is the basic process for magnetic flux tubes and ADP$\leftrightarrow$ ATP has been assigned to this process with ATP molecule serving as a relay activating the flux tube connection. Maybe ADP-ATP process, which is usually seen as a basic step of metabolism, could be seen as the core step for quantum computation performed by living matter. One expects that the presence ATP makes the rule represented by negentropic quantum entanglement conscious.

Quantum computation magnetic flux tubes as connections

Consider now quantum computation could take place in a circuitry having magnetic flux tubes as wires and some bio-molecules of groups of them as units defining prime functions. DNA as topological quantum computer could be taken as a starting point. The outcome of quantum computation is determined statistically as ensemble average so that a large number of copies of the program should be present and realized in terms of groups of cells or molecules connected by braidings if the quantum computation is space-like. This option seems more natural than time-like quantum computation realized as a 2-D liquid flow of lipids in the lipid layers of the cell membrane.

1. The hardware

Consider first the hardware of topological quantum computation using space-like braids.

1. Magnetic flux tubes would represent the wires along which inputs and outputs travel in the case of classical computation or dynamical quantum computation. In the case of space-like topological quantum computation entanglement is between the ends of the flux tubes.

2. Variables could be represented in many ways. For space-like quantum computations they could correspond to spin states of dark electrons at flux tubes or to polarization states of dark electrons at the flux tubes. In the original model of DNA as topological quantum computer quarks and antiquarks where proposed as a representation of genetic codons: also this quite science fictive option could make sense in TGD Universe since TGD predicts scaled versions of QCD like dynamics and presence of elementary particles in several p-adic scales and in scales dictated by value of Planck constant for given p-adic length scale.

   The spin states of electron pair has been proposed as one possible representation of the 4 genetic codons. Quantum variables would be represented by qubit sequences and the measurement of qubit would give a bit sequence characterizing the classical value of the variable. Bio-molecules would be natural places for storing the values of the variables. For dynamical computations the values of variables could be transmitted using dark photons.

3. There would exist basic processing units calculating the prime functions from which more complex functions would be obtained as composites. Basic units could correspond to bio-molecules. In the case of classical computation the inputs to molecules and outputs from them would travel along the flux tubes. In quantum computation these signals could be used to control the initial values of the variables. Molecules could also serve as gates for quantum computation.

2. Representation of programs

The basic program units in the case of quantum computation would be represented by braidings.

1. If the ends of braid strands are able to move freely when needed, it becomes possible to re-write programs. Lipid layers of cell membrane can be in liquid crystal state so that these are ideal for this purpose. The time-like braiding resulting from lipid flow and representing running topological quantum computation program would induce space-like braiding representing space-like topological quantum computation or a rule. A particular quantum computer program represented as space-like braiding of the flux tubes would result as liquid crystal melts for a moment and freezes again.

Protein aggretion process (see `http://tinyurl.com/yarrblxn`) in which proteins covered by ordered water analogous to ice temporarily melt and form aggregates [I24] is basic process induced by the feed of energy to the cellular system and could be compared to cellular summer. This process could mean quite generally molecular re-programming induced by the flow of cellular water inducing molecular flows inducing re-braidings. The braiding would also store the highlights of the cellular summer to cellular memory! This could be also seen learning by a modification of various quantum computer programs.

2. Negentropic entanglement is highly suggestive and would conform with the idea that the rule represented by entanglement represents conscious information or information which can become conscious. The process of becoming conscious information could involve ATP$\rightarrow$ ADP and de-activating the flux tube and destroy the information. Time-like braiding represented by liquid flow would modify space-like braiding.

It is not quite clear whether the information is conscious when negentropic entanglement (and ATP) is present - as Bohm's notion of active information (see `http://tinyurl.com/qhx3suy`) [J91] would suggest - or when ATP is transformed to ADP and connection becomes passive. Negentropic entanglement can be stable with respect to NMP (see `http://tinyurl.com/yd3mly5m`) [K70] so that the presence of ATP could mean period of conscious experience - negentropic entanglement could be analogous to active information.

TGD based model for the memory recall by sending negative energy signals to geometric past suggests that the absorption of negative energy photon transforms ATP to ADP. Conscious experience is regenerated in the geometric now where the negative energy signal came from - perhaps by transforming ADP to ATP by using the negative resulting by sending of negative energy signal! Conscious reading would be actually memory recall and analogous to teleportation? The destruction of the representation of memory in the geometric past would have interpretation in terms of no-cloning theorem (see `http://tinyurl.com/2dhl4oe`) [B5].

3. Static realizations of the programs are easier to imagine since no temporal codes are needed for the transfer of bits. An attractive idea is that the computations are represented by static entanglements for linear structures and that time-like braiding allows to modify the programs.

3. The realization of program

The program would be basically a sequence of address lists. Address list would contain the address of the function to be performed and the addresses of the input molecules and output molecules. How to represent the address physically?

1. The simplest manner to realize this would use existing flux tubes connecting the processing unit to all possible input and output addresses as well as command addresses, and activate those flux tubes to which input and output data are assigned and reconnect them to the flux tubes connecting processing unit to the unit representing the function. The processing unit would have flux tubes coming from all possible inputs, going to all possible outputs, flux tubes going to places representing functions and coming from these places. Processing unit would be like a relay station or old fashioned telephone center whose sole purpose would be to create connections by reconnecting flux tubes. ATP molecule would be probably involved with the activation and - allowing a sloppy language - one could say that communication line becomes conscious when ATP is attached to it.

   (a) Addressing would be just selection of activated molecules and analogous to that used in telephone network or computer network connected by cables. This would require static flux tube network and flux tubes could be either active or passive. In passive state flux tubes could be short-cut by a reconnection with hydrogen bond so that the ends of cut flux tube would end up to water molecules. This is however not necessary. Activation in absence of the short cut would involve reconnection of a flux tube with a flux tube connecting two parts of ATP - possibly hydrogen bond again- so that ATP becomes part of the flux tubes. If also short cut is involved, the strands coming to the two water molecules reconnect and generate hydrogen bond and flux tube to which ATP would

attach in the proposed manner. As ATP is used it transforms to ADP and de-attaches from the flux tube.

(b) One can imagine also a dynamical addressing based on the generation of magnetic flux tubes between inputs and submodules. The computational process could be still space-like. The first manner to realize dynamical addressing would be by attaching to the ends of dynamical flux tubes biomolecules, which bind to specific receptors. Receptor mechanism would allow to connect distant cells to each other and build a magnetic flux tube connection between them. Computational unit specialized to run a specific program could excrete biomolecules binding to the input and output receptors: this program would realized function in terms of space-like entanglement. Glands (see `http://tinyurl.com/cxjro9z`) excrete hormones binding to receptors and various glands could in principle serve as computational units. Various information molecules bind very selectively and this might also relate to quantum space-like computations.

(c) Second mechanism of dynamical addressing would use dark photons. In this case resonant interaction selecting the target would replace the receptor mechanism. In this kind of situation one can claim that flux tubes are un-necessary, one can use just resonance to build connection to a desired place just as one does in radio communications. Of course, topological light rays could be accompanied by flux tubes. For instance, DNA nucleotide could attach by flux tube to its conjugate in distant DNA molecule and if the connection is based on resonance only similar nucleotide sequences could connect with each other. I have discussed this kind of mechanism in a model for remote replication of DNA (see `http://tinyurl.com/ybvosy7h`) [K127] based on the experimental work by Peter Gariaev and his group. The resonance mechanism could also make possible to establish flux tube connections and the quantum computation could be a static operation.

2. DNA as topological quantum computer vision gives some idea about how the computer program could be realized as a spatial linear structure.

(a) Program would be a sequence of topological quantum computations. Given topological quantum computation would be represented by a braiding of flux tubes connecting DNA nucleotides with the lipid molecules of the inner lipid layer. Program would correspond to a linear sequence of cells with the outer lipid layer connected to the DNA of the second cell.

(b) Lipid flows at given lipid layer could be used to rewrite programs and the programs could respond to the changes in environment in this manner: this would require that the lipid layer is in liquid crystal state during the period when program is changed. Also nerve pulse patterns would induce these flows. Programs would also represent memories as rules realized as quantum abstractions or as quantum functions.

(c) The program would "run" in the spatial direction. The selection of active input and output variables would be by acting the connection from molecule in question by attaching ATP as a relay through which the reconnected flux tube would traverse. This would be also part of the writing of the program. The superposition of entangled inputs and outputs could be seen as a quantum superposition of classical programs assigning outputs to inputs. Also microtubule-lipid layer braiding suggested also to play a key role in the realization of memories could give rise to similar space-like quantum computation representing rules.

(d) The effective 2-dimensionality implied by strong form of holography implied in turn by strong form of general coordinate invariance means that the physics depends on partonic 2-surfaces and 4-D tangent space data at them. This suggests that the dynamics on space-like 3-surfaces and light-like orbits of partonic 2-surfaces is fixed by a process analogous to gauge selection. Does just this effective gauge symmetry make possible to write quantum computer programs? Already ordinary deterministic computer program means selection of one particular dynamics from several alternative options suggesting that strict determinism is broken.

3. What could be the role of bio-catalysis in the computation? Bio-catalysis is a central part of the biological information processing and it would not be surprising if the catalysts connected by flux tubes to substrate molecules were involved with the computations. An attractive idea is that various information molecules binding to receptors involved with bio-control (neurotransmitters, hormones, etc...) are involved with building the flux tube connections between cells. These bio-molecules could carry the ends of flux tubes to special places for which receptors serve as addresses and in this manner build hardware for topological quantum computation involving inputs and outputs in distant parts of the body. The final output could be transformed to controlled gene expression. Quite generally, catalysts bind very selectively and could play a role similar that played by information molecules in building up the quantum computer programs.

4. One can imagine also purely classical computation based on catalytic mechanism probably allowing generalization to quantum case. The idea is that computer program - understood now as dynamical structure - is analogous to what happens in fairy tale in which hero finds a key which fits to a lock of a room containing a key which... There exists a beautiful realization of classical computation in terms of chemical concentrations using DNA. The output of given reaction representing computational step appears in the next reaction provide the system contains additional participating molecules, which could be both substrate molecules and catalysts. The program could be represented as concentrations of molecules needed at intermediate steps and lock-to-key mechanism guarantees that they are performed in the correct temporal order. Inputs and output molecules could be connected by flux tubes to bio-molecules which bind to specific receptors associated with the molecule representing the particular subprogram. This would automatically create a large number of classical computations proceeding in fixed order, maybe even quantum computations.

2.2.8   DNA As Topological Quantum Computer

The vision about how DNA might act as a topological quantum computer (TQC) [B17] is few years old [K5]. TQC means that the time-like braidings of braid strands define TQC programs and M-matrix (generalization of S-matrix in zero energy ontology) defining the time-like entanglement between states assignable to the end points of strands define the TQC program coded as unitary time evolution for Schrödinger equation in the standard framework. One can end up to the model in the following manner.

1. Darwinian selection for which the standard theory of self-organization provides a model, should apply also to TQC programs. TQC programs should correspond to asymptotic self-organization patterns selected by dissipation in the presence of metabolic energy feed. The spatial and temporal pattern of the metabolic energy feed characterizes the TQC program - or equivalently - sub-program call.

2. Since braiding characterizes the TQC program, the self-organization pattern should correspond to a hydrodynamical flow or a pattern of magnetic field inducing the braiding. Braid strands must correspond to magnetic flux tubes of the magnetic body of DNA. If each nucleotide is transversal magnetic dipole it gives rise to transversal flux tubes, which can also connect to the genome of another cell. As a matter fact, the flux tubes would correspond to what I have used to call wormhole magnetic fields [K125] having pairs of space-time sheets carrying opposite magnetic fluxes. The wormholes themselves could have interpretation as dark scaled variants of ordinary elementary particles. The large value of Planck constant would zoom up the magnetic fields associated with ordinary elementary particles from weak scale to much longer length scale given by cell size or even a longer length scale.

3. The output of TQC sub-program is probability distribution for the outcomes of state function reduction so that the sub-program must be repeated very many times. It is represented as four-dimensional patterns for various rates (chemical rates, nerve pulse patterns, EEG power distributions, ...) having also identification as temporal densities of zero energy states in various scales.

By the fractality of TGD Universe there is a hierarchy of TQCs corresponding to p-adic and dark matter hierarchies. Programs (space-time sheets defining coherence regions) call programs in shorter scale. If the self-organizing system has a periodic behavior each TQC module defines a large number of almost copies of itself asymptotically. Generalized EEG could naturally define this periodic pattern and each period of EEG would correspond to an initiation and halting of TQC. This brings in mind the periodically occurring sol-gel phase transition inside cell near the cell membrane. There is also a connection with hologram idea: EEG rhythm corresponds to reference wave and nerve pulse patterns to the wave carrying the information and interfering with the reference wave.

4. Fluid flow would naturally induce the braiding which requires that the ends of braid strands must be anchored to the fluid flow. Recalling that lipid mono-layers of the cell membrane are liquid crystals and lipids of interior mono-layer have hydrophilic ends pointing towards cell interior, it is easy to guess that DNA nucleotides are connected to lipids by magnetic flux tubes and hydrophilic lipid ends are stuck to the flow. Also nerve pulse patterns could induce the flow of lipids inducing the braiding so that nerve pulse patterns would define TQC programs and be coded into memories.

5. The topology of the braid traversing cell membrane cannot be affected by the hydrodynamical flow. Hence braid strands must be split during TQC. This also induces the desired magnetic isolation from the environment. Halting of TQC reconnects them and make possible the communication of the outcome of TQC.

This is one possible realization and it is of course clear that one can imagine several alternatives. There are several problems related to the details of the realization.

1. How nucleotides A, T, C, G are coded to the strand color and what this color corresponds to physically? The original proposal was that there are two options which could be characterized as fermionic and bosonic.

   (a) Magnetic flux tubes having quark and anti-quark at their ends with u, d and u_c, d_c coding for A, G and T, C. CP conjugation would correspond to conjugation for DNA nucleotides.

   (b) Wormhole magnetic flux tubes having wormhole contact and its CP conjugate at its ends with wormhole contact carrying quark and anti-quark at its throats. The latter are predicted to appear in all length scales in TGD Universe.

   Recently it became clear that there is much simpler realization involving only spin 1/2 fermion pairs assignable to pairs of flux tubes. The spin states of fermion pairs form triplet and singlet and code for A, T, C, G. The first guess is that fermion is proton or electron but this does not allow coding of color qualia. Taking fermion to be u quark one can realize color qualia in terms of quark color and has good hopes about Coulomb stability since the charge assigned to nucleotide reduces from -2 to -2/3 (Coulomb stability of DNA is a well-known problem). Flux tubes are ordinary flux tubes. One ends up also to a concrete model for happens when color qualia are generated. An unexpected bonus is that statistics constraint implies that color and spin entanglement forces spatial entanglement realized as braiding of the flux tubes so that entanglement indeed has classical space-time correlate.

2. How to split the braid strands in a controlled manner? High T_c super conductivity provides a possible mechanism: braid strand can be split only if the supra current flowing through it vanishes. A suitable voltage pulse induces the supra-current and its negative cancels it. The conformation of the lipid controls whether it it can follow the flow or not.

3. How magnetic flux tubes can be cut without breaking the conservation of the magnetic flux? The notion of wormhole magnetic field could save the situation now: after the splitting the flux returns back along the second space-time sheet of wormhole magnetic field. An alternative solution is based on reconnection of flux tubes. Since only flux tubes of same color can reconnect this process can induce transfer of color: "color inheritance": when applied at the level of amino-acids this would give strong constraints on the model of protein

folding [K10]. Reconnection makes possible breaking of flux tube connection for both the ordinary magnetic flux tubes and wormhole magnetic flux tubes.

4. How magnetic flux tubes are realized? The interpretation of flux tubes as correlates of directed attention at molecular level suggests a rather concrete picture. Hydrogen bonds are by their asymmetry natural correlates for a directed attention at molecular level. Also flux tubes between acceptors of hydrogen bonds must be allowed and acceptors can be seen as the subjects of directed attention and donors as objects. Examples of acceptors are aromatic rings of nucleotides, $O =$ atoms of phosphates, etc.. A connection with metabolism is obtained if it is assumed that various phosphates $XMP, XDP, XTP, X = A, T, G, C$ act as fundamental acceptors and plugs in the connection lines. The basic metabolic process $ATP \rightarrow ADP + P_i$ allows an interpretation as a reconnection splitting flux tube connection, and the basic function of phosphorylating enzymes would be to build flux tube connections as also of breathing and photosynthesis.

The model makes several testable predictions about DNA itself. In particular, matter-antimatter asymmetry and slightly broken isospin symmetry at the level of dark quarks have counterparts at DNA level induced from the breaking of these symmetries for quarks and antiquarks associated with the flux tubes. DNA cell membrane system is not the only possible system that could perform TQC like activities and store memories in braidings: flux tubes could connect biomolecules and the negentropic braiding could provide an almost definition for what it is to be living. Even water memory might reduce to braidings.

The model leads also to an improved understanding of other roles of the magnetic flux tubes containing dark matter. Phase transitions changing the value of Planck constant for the magnetic flux tubes could be key element of bio-catalysis and electromagnetic long distance communications in living matter. There is also a fascinating connection with Peter Gariaev's work [I95] suggesting that the phase transitions changing Planck constant have been observed and wormhole magnetic flux tubes containing dark matter have been photographed in his experiments [K116].

2.2.9 What Is The Role Of Magnetic Body In DNA Replication, Mitosis, Meiosis, And Fertilization?

If magnetic body uses biological body as a motor instrument and sensory receptor, the natural question is whether basic process such as mitosis, meiosis. could be induced by more fundamental processes for the magnetic body. One can argue that if magnetic flux tubes are responsible for making living organism and even population a kind of Indra's net, cell division should be induced by magnetic body and should produce automatically this Indra's net.

As a matter of fact, cell division brings strongly in mind division of magnetic dipole but also the reconnection of magnetic flux tubes can be considered as a basic mechanism. At least the following basic mechanisms can be considered.

1. Consider a pair of magnetic flux tubes with opposite fluxes connecting objects A and B. The division of A+B to A and B would be induced by a reconnection process for the members of the pair producing two loops associated with A and B but no connection between A and B anymore. The problem of this option is that the flux tube connection defined in this manner might not be stable enough.

2. Magnetic dipole would correspond to a flux tube at the core of the dipole field itself decomposing to flux tubes with weaker magnetic flux at its ends. The division to two dipoles would correspond to a formation of segment in which flux tube decomposes into several flux tubes, which need not be parallel anymore. Two new dipole ends are formed and the old dipole ends remain connected so that the repetition of this process would yield a kind of Indra's net predicting that all cells of living organism are connected by the flux tubes to single coherent whole.

The division of flux tube to several flux tubes could also correspond to the increase of Planck constant by integer factor n along a segment of flux tube. The resulting n flux sheets would corresponds to the sheets of the covering. The length of the segment would be scaled up by n.

3. If one has pair of dipoles A-B and C-D with same total flux, a reconnection leading to A-D and C-B is possible.

Could biochemical processes associated with cell division be induced by some of the listed processes? The two latter options would predict that the cells produced in cell division remain connected by magnetic flux tubes. The division of dipole creates two new dipole ends connected by short flux tube. The already existing ends remain connected by "long" flux tubes carrying weak magnetic fields as compared to that carried by the dipole itself. Also the processes of meiosis and fertilization could respect the presence of long flux tubes connecting the cells participating in the process so that flux tube connections could also exist between parents and offspring. The members of population could form a kind of super-organism. Remote interactions between DNA and other biomolecules of closely related members of species and even shared use of DNA (and its TGD variant "dark DNA") can be imagined.

1. Consider first DNA replication and reshuffling taking place in meiosis (see `http://tinyurl.com/25jmwu`) [I19] essential for the sexual reproduction in eukariotes. The dividing nucleus (of form MMFF) is ordinary nucleus and contains two pairs of chromosomes coming both mother (MM) and father (FF). Division produces four haploid cells containing only two chromosomes (AB) with A and B obtained by reshuffling the DNAs of mother and father to obtained 4 unique chromosome pairs. In sexual reproduction these cells fuse to form diploid cells (MMFF).

   (a) The reshuffling of a pair MF of DNA strands from father and mother could be induced by a repeated reconnection process for flux tubes parallel to DNA strands. The simplest reconnection for strands A-B and C-D produces strands A-X-D and C-Y-B where A-Z and C-Y are pieces of A-B and C-D with same number of codons.

   (b) The replication of DNA takes place for all four chromosomes before reshuffling. One obtains a nucleus containing 4 pairs of doubled chromosomes. This double nucleus divides to two daugher nuclei containing 2 doubled chromosomes each.These divide further to two nuclei each containing only two chromosomes each (AB).
   The DNA reshuffling could correspond to a multiple reconnection process if the two DNA strands are accompanied by by long magnetic dipoles (flux tubes). Note that in absence of additional restrictions many combinations (28) are possible.

   (c) After replication and reshuffling the division of the nucleus two two intermediaries could be induced either by splitting of a flux tube connecting pairs of doubled chromosomes to flux tubes not anymore parallel to each other. The flux could diverge to a larger volume in this segment. Second possibility is that the increase of Planck constant increases the length of segment and at the same time divides the flux into sub-fluxes. Dipole field flux tube would give long flux tubes and split dipole shorter flux tubes connecting the resulting cells together.

   (d) Also the chromosome pairs of the resulting intermediate nuclei could be connected to each other by flux tubes to form a connected structure A-B-C-D and reconnection process could divide it to A-B plus C-D (say) and lead to a division of the nucleus producing 4 ordinary daughter nuclei.

2. In mitosis (see `http://tinyurl.com/69lfln`) [I20] the initial nucleus corresponds to MMFF and DNA replication leads to pairs of doubled chromosomes but without re-shuffling. One doubled pair from mother and one pair from father the members of doubled chromosomes are connected by a kind of bridge. In the mitosis proper the doubled chromosome pairs are split and two chromosome pairs containing one chromosome from father and mother are formed. After this division leads to two diploid cells similar to the dividing cell.

3. In fertilization (see `http://tinyurl.com/2tzd6k`) [I12] gametes from father and mother fuse together to form a single cell with two pairs of chromosomes from both father and mother. The question is how the two gametes are able to find each other. The reconnection of closed magnetic flux tubes associated with the gametes could lead to a formation of bridges connection the two gametes and a phase transition reducing the value of Planck constant could lead the two gametes near each other and make possible the fusion.

DNA replication (see http://tinyurl.com/2tbv2d) [I10] is clearly the fundamental process, and the question is whether also this step could be reduced to a reconnection for a pair flux tubes: first would connect the separated DNA strands and second one free nucleotide and its conjugate.

1. Suppose that there are flux tubes connecting nucleotides of DNA and corresponding nucleotides of the conjugate strand: they could be rather short flux tubes of length shorter than 1 nm in the normal situation but could grow longer when DNA strands separate. This might involve a phase transition increasing temporarily the value of Planck constant assignable to these flux tubes and increasing the length of the segment and of connecting flux tube and therefore the distance of DNA strands.

2. There are also free DNA nucleotides and their conjugates in the environment which can be used in the replication process as building bricks. If also free nucleotides and their conjugates are connected in a pairwise manner by similar flux tubes and if the value of magnetic flux characterizes a given pair then reconnection could take place for these two kinds of flux tubes and lead to a correct pairing of DNA strand with conjugate nucleotides. Same would happen for the conjugate strand. The reduction of Planck constant would lead to a pair of ordinary DNA double strands.

3. The details of the dynamics would be determined by other factors but the outcome would be fixed by the nucleotide-conjugate pairing and dependence of the flux on the nucleotide pair. In particular, conservation of magnetic flux would guarantee that the nucleotides can be assigned only with their conjugates.

These arguments suggest that reconnection of magnetic flux tubes, temporary change of the Planck constant, and coding of nucleotide-conjugate pairs by magnetic flux could be key element of meiosis, mitosis, and reshuffling of chromosomes in meiosis. Also higher level processes - such as cell division and fertilization - could involve reconnection process as a fundamental step. These mechanisms would appear in several length scales corresponding to DNA, nucleus, and cell length scale. In an approach based on mere chemistry, this must be assumed as a result of kinematics.

2.2.10 Three pieces of evidence for the notion of magnetic body

Evidence for the notion of magnetic body has started to accumulate. The following discusses three rather recent pieces of evidence.

Evidence for the notion of magnetic body from brain synchrony without corpus callosum

The notion of magnetic body is central for the entire TGD based approach to living matter and it would be important to find experimental support for it. Quite recently I received a link to a rather baffling finding about brain [J69] (see http://tinyurl.com/3gjhtgb). Neuroscientists have believed that the two hemispheres communicate via the neural pathways associated with corpus callosum: kind of communication cables would be in question. Many areas of brain behave synchronously, which has led to the notion of resting state network.

The team led by Michael Tyszka, associate director of Caltech Brain Imaging Center, has however discovered that the resting state network seems to work normally in people born without corpus callosum! As if brain hemispheres were communicating by some other means than neural signalling! This finding challenges not only the views about the origin of brain synchrony as being created by neural circuits but also the models of autism and schizophrenia explaining them in terms of impaired communications between hemispheres.

One can for instance speculate with the possibility that there is electromagnetic communication between brain hemispheres. This does not look a bad idea at all: nowadays it is possible to extract information about EEG so that pilots are able to control the flight of tiny flying object by imagining what the object should do. Technological applications will probably appear in the market soon so that anyone can have robots controllable by thoughts.

This mechanism is consistent with the TGD inspired view about brain. This view however encourages to consider also a more imaginative explanation. In TGD Universe living system

involves besides organism and environment also magnetic body (MB) acting as an intentional agent receiving sensory input from organism and controlling it. MB has hierarchical onion-like structure. For instance, brain hemispheres have their own MBs, and entire brain its own MB serving as a "boss" for the MBs of hemispheres.

Communications between magnetic body and part of organism take place using dark photons having non-standard value $h_{eff} = n \times h$ of Planck constant and thus energy $E = h_{eff}f$, which should correspond to ordinary photons with energies above thermal energy: otherwise quantal effects are masked by thermal fluctuations. Bio-photons in the visible and UV range could result in the transformation of dark photons to ordinary photons. The frequency range of dark photons depends on the level of the layer of MB characterized by h_{eff} and wavelength corresponds to the size scale of the layer.

In the case of brain the transfer of sensory information to MB would be realized as EEG - wavelength of 7.8 Hz radiation is order of the circumference of Earth so that MBs for brain would be really large. In Zero Energy Ontology (ZEO) control signals would be realized as negative energy signals propagating backwards in geometric time and having phase conjugate laser light as a counterpart in ordinary physics. This explains Libet's finding that neural activity precedes conscious decision. Coordination by using EEG rhythms would be part of control analogous to work songs.

The MB of entire brain controls it and could naturally do this via the intermediate control of brain hemispheres forcing them to operate in the same rhythm. Brain synchrony and resting network would not be produced by resonant neuro-circuits as usually believed but by the spatiotemporal coherence of the EEG radiation from the MB of entire brain forcing brain hemisphere MBs to oscillate in the same rhythm and in turning synchronizing the brain hemispheres. This would be like forcing soldiers to march in the same pace and brain hemispheres could co-operate without any neural communication between hemispheres. The communication between hemispheres would be needed for more refined collaboration involving "discussion" between hemispheres: hemispheres of a person without corpus callosum would be like soldiers obeying blindly the orders. This might be also an essential element of autism and schizophrenia.

Magnetic body and magnetic sense

Humans seem to have sixth sense: kind of sub-conscious magnetic sense of directions (see `http://tinyurl.com/j8rqskj`) possessed by many animals lower in the evolutionary tree - in particular birds and fishes and also many mammals. There is evidence that also humans but not all of us and not always - seem to respond to magnetic field.

Geophysisicist Joe Kirschwink working at CalTech as professor of geobiology is already familiar to me. For instance, Kirscwink has introduced the term "snowball Earth". Kirscwink claims that he has proven that also humans have magnetic sense serving as a kind of compass. The experiment involves a slowly rotating constant magnetic field with strength between .25-.6 Gauss (Earth's magnetic field has nominal value of .5 Gauss and the "endogenous" magnetic field appearing in TGD inspired quantum biology has value about .2 Gauss). The field is created by coils located at the walls of a cube s o that its direction is under control and it can be also cancelled. The subject person sits in the middle of a Faraday cage eliminating electromagnetic perturbations from environment ad her EEG is measured. The explanation for why the earlier experiments often failed is that external perturbations cancelled the effect.

What was found that when the applied field rotates counterclockwise there is a response: the intensity in EEG alpha band drops down. The response however appears few hundred milliseconds later than one would expect if the response is passive response due to the electric currents induced by the applied field in brain. The signal appeared for up-down direction and counter-clockwise rotation but not the opposite. It also appeared when the direction of the field "yawed into the floor". I take yaw to mean the orientation angle of magnetic field with respect to the vertical axis.

A slow counterclock-wise rotation of the applied field was necessary. It was not mentioned how slow this rotation was. The rotation of the applied field mimicked the effect produced by the rotation of head with respect to the magnetic field of Earth, which is in good approximation non-rotating in the inertial frame of person. In TGD framework one can ask whether parity breaking effect in macroscopic length scales was involved. What comes in mind is the rotation of the water going down to drain taking always in clocwise direction. Magnetic field obeys same equation as

incompressible hydrodyamic flow. Could it be that the magnetic field associated with magnetite sensors in magnetic receptor neurons rotates in clockwise direction much like water going in drain and the response is maximal when the rotation directions are opposite?

One can probably invent purely neuroscientific explanations for the time lag of few hundred milliseconds for EEG response (EEG consists of quasistationary pieces of duration about .3 seconds possibly identifiable as correlates of mental images). In TGD framework the lag could be understood i as being due to the fact that the percept is communicated to MB responding by reducing the alpha wave responsible synchronization of the brain. This response could be kind of wake-up from synchrony.

Does the magnetic body of Earth protect planet's atmosphere from cosmic rays?

Third piece of evidence for MB comes from NASA (see `http://tinyurl.com/j57h32u`). MIT scientists have found what the article calls mysterious "invisible" force field protecting planet's atmosphere by preventing cosmic ray radiation entering to the lower atsmosphere. The field was first noticed by two NASA spacecrafts orbiting in van Allen radiation belt at height of 11,000 km (Earth radius is 6,371 km). The field blocks highly radioactive higher energy electrons. These electrns are attracted towards Earth by the magnetic field of Earth but cannot approsch planet closer than 13,300 km - slightly more than twice the Earth radius.

Low frequency electromagnetic fields are involved as with dark matter at magnetic bodies. My guess is that the guardian angel is the magnetic body of Earth carrying dark matter to which one can assign magnetic field strength of .2 Gauss (2/5 of the nominal value of the Earth's magnetic field): actually entire spectrum of values is expected. The flux tubes or sheets carry dark matter and it could absorb the cosmic rays and tame them to Bose-Einstein condensates. For large $h_{eff} = n \times h$ the high energy E of cosmic ray corresponds to very low frequency $f = E/h_{eff}$ and very long wavelength of order Earth size scale. Ordinary cosmic ray would be transformed to dark cosmic ray with very long wave length. The effect of ordinary cosmic ray is in scale of wavelength and highly local and disastreous for biomolecules like DNA. Now the affect would be absent. Dark magnetic body would act like mattress.

2.3 The Relationship Between Information Processing And Metabolism In TGD Universe

After the writing of the first version of this chapter for about decade ago several new ideas have emerged and the challenge is to unify these ideas.

2.3.1 Three Different Views About Living Matter As A Macroscopic Quantum System

There are three different views about how living system manages to be a macroscopic quantum system.

1. The first vision is based on various kinds of super-conductivities [K25]. Electronic super-conductivity is assigned with the cell membrane and plays a key role in the model of cell membrane as a Josephson junction. Furthermore, the effects of ELF em fields on vertebrate brain [K44] suggest that biologically important ions form macroscopic quantum states and cyclotron Bose-Einstein condensates of bosonic ions have been suggested. The TGD based view about atomic nuclei predicts exotic nuclei chemically equivalent with ordinary ones but being bosons rather than fermions. Also these exotic ions could also form cyclotron Bose-Einstein condensates. Large value of Planck constant would guarantee that cycloctron energies proportional to $\hbar$ are above thermal energy.

2. A more precise view about hierarchy of Planck constants as an implication of the enormous vacuum degeneracy of Kähler action has emerged [K46]. According to this view non-standard values of Planck constant are only effective.

   As the idea about the hierarchy of Planck constants emerged, I proposed that favored values of Planck constant could comes are powers of 2^{11}. This was just a first guess inspired partially

by the observation that the mass ratio of proton and electron is $940/.5 = 1880 \sim 2^{11}$. I managed to find indications supporting this hierarchy and also this chapter contains traces of this idea. I became later skeptic but one could actually imagine a mechanism implying this kind of hierarchy. Dark protons with say $r = \hbar/\hbar_0 = 1836 = 4 \times 3^3 \times \times 17$ would correspond to approximately same Compton length as ordinary electrons. It is natural to assign this value of $\hbar$ also to electrons and this gives Compton length 44.6 Angstroms not far from the p-adic length scale $L(149) \simeq 50$ Angstroms assigned with the lipid layer of cell membrane. The condition that dark proton corresponds to this Compton length gives $r = 1836^2$: the electron Compton length comes now 8.1 μm, which corresponds to cell size scale. One could continue the resulting hierarchy of Planck constants indefinitely.

3. The notion of negentropic entanglement making sense for rational and even algebraic entanglement probabilities has emerged as a possible characterizer of living matter [K70]. Quantum arithmetics [K80] allows to generalize the notion of rational so that p-adic real correspondence mediated by canonical identification is fixed uniquely and is both continuous and respects symmetries [K80]. One implication is an explanation for Shnoll effect [K11], which could be important also in living matter.

   This raises several questions.

1. How high T_c super conductivity based on dark electron pairs and negentropic entanglement relate?

2. Could it be that electron pairs in valence bonds are the carriers of negentropic entanglement (see **Fig. http://tgdtheory.fi/appfigures/cat.jpg** or **Fig. ??** in the appendix of this book) and that they generate the magnetic flux tubes as parts of their magnetic bodies? This makes sense only if the valence electron pairs in living matter have spin 1. The Cooper pairs of high T_c super-conductors are ineed known to have spin 1 [**?**] If this view is correct, biological evolution would favor the maximization of covalent electron pairs and this indeed seems to be the case.

3. Why large $\hbar$ would make possible negentropic entanglement or even force it? Is there some purely number theoretic reason for this?

2.3.2 New Ideas Related To Metabolism

Also new ideas related to metabolism have emerged at the same time when evidence for quantal aspects of photosynthesis has been emerging [I87, I29, I26, I11]. The ideas about the detailed relationship between metabolism and negentropic entanglement are still in a state of turmoil. Let us sum up those concepts and ideas which could serve as starting point.

1. Negentropic entanglement is the first basic notion. There is a strong tendency to consider the presence of a magnetic flux tube connecting two objects and carrying negentropically entangled quantum state as a fundamental structure giving rise to a directed attention. Negentropic entanglement would be basic element of conscious cognition, and one can assign to it various attributes like experience of understanding. The mildest assumption is that negentropic entanglement is associated with the flux tube. A stronger assumption is that it is between states assignable to the ends of the flux tube identifiable as observer and target of attention.

   An analogy with Orch OR is suggestive. The period of negentropic entanglement - period of directed attention - would correspond to Orch Or and its end to state function reduction.

2. Negentropic entanglement leads also to the idea about energy metabolism and negentropy transfer as different sides of the same coin. The model for DNA as topological in turn suggest that ADP $\rightarrow$ ATP and its reverse can be interpreted as a standardized reconnection process re-organizing connections between distant molecules connected by magnetic flux tubes by the relay defined by ATP molecule. Metabolic energy would - or at least could - go to the re-organization of the flux tube connections and therefore of the negentropic quantum entanglement. The question is how to fuse this vision with the hypothesis about metabolic currencies as differences of zero point kinetic energies for space-time sheets.

3. An attractive interpretation is that the presence of ATP at magnetic flux tube serves as a signature of negentropic entanglement. The period of negentropic entanglement could be seen as the analog of Orch OR period ending with state function reduction. This period would be accompanied by consciousness to which one can assign various attributes such as experience of understanding and positively colored emotions. It is of course difficult to say what the counterparts of these experiences are at the level of flux tubes. One can imagine two options.

    (a) The high energy phosphate bond in ATP is the carrier of the negentropic entanglement. The transformation of ATP to ADP would liberate the metabolic energy and mean end of the period during which one can assign negentropic entanglement to the flux tube. ATP would be the correlate for consciousness at the flux tube level - the molecule of consciousness.

    (b) ATP $\rightarrow$ ADP transfers metabolic energy quantum to the magnetic flux tube and creates a excited with negentropic entanglement. This process could correspond to either generation of negentropic entanglement (period of negentropic entanglement would begin with ATP$\rightarrow$ ADP rather than end) or transfer of it from ATP to the flux tube.

4. The radiation from Sun defines the fundamental metabolic currency. Solar radiation cannot be said to negentropic since negentropic entanglement is a 2-particle property. Solar photons could possess a large value of $\hbar$ or - more plausibly - suffer at the magnetic body of the living system a phase transition increasing the value of $\hbar$. Could the absorption of large $\hbar$ photons arriving from Sun or from magnetic body by electrons generate spin 1 valence electron pairs pairs or provide the metabolic energy needed to re-arrange the flux tube connections between distant molecules by $ADP + P_i \rightarrow ATP$ process?

5. The identification of the increments zero point kinetic energies as universal metabolic energy quanta is one of the oldest hypothesis of TGD inspired theory of consciousness. Zero point kinetic energy is associated with the zero point motion of particle at space-time sheet. The finite size of the space-time sheet gives rise to this energy for which non-relativistic parameterization is $E_0 = k \times 3\hbar^2\pi^2/2mL^2(k)$. $L(k) = 2^{(-k+151)/2}L(151)$, $L(151) \simeq 10$ nm is the p-adic length scale of the space-time sheet, and k numerical factor not far from unity. Particle in 3-D box gives $k = 1$.

As particle is transferred to a larger space-time sheet the zero point kinetic energy is reduced, and the difference is liberated as usable metabolic energy. For proton the size scale of this space-time sheet could be atomic size scale $k = 137$. For electron it could electron Cooper pair $k = 149$ (prime) corresponding to a lipid layer of cell membrane could be in question. Entire hierarchy of metabolic energy quanta is predicted and the energy scale depends on the particle mass and p-adic length scale and geometric factors characterizing the shape of space-time sheet only.

One can ask whether the high energy phosphate bond in the phosphate of ATP molecule contains this kind of smaller space-time sheet and in the transition ATP $\rightarrow$ ADP, electron or proton drops from this kind of space-time sheet. The following considerations show that this hypothesis is not necessary, and that one can also modify the identification of the fundamental metabolic energy quantum as zero point kinetic energy without losing anything. Therefore the details of the scenario are far from being fully nailed down.

6. Magnetic flux tubes are carriers of charged particles and the hypothesis is that cyclotron Bose-Einstein condensates for fermionic Cooper pairs and bosonic ions are relevant for consciousness. In particular, cyclotron transitions in which bosons in these condensates are excited would be important for the generation of conscious experiences. The hierarchy of Planck constants and the fact that cyclotron energy is proportional to $\hbar$ allows to have arbitrarily high cyclotron energies in given magnetic field. This is essential in the model for the effects of ELF em fields on living matter [K17].

7. Becker's finding about the relevance of DC currents for healing of wounds lead to an idea about how electromagnetic radiation interacts with the charged particles at magnetic flux

tubes [L12]. What would happen is that charged particles experience the electric and magnetic fields of the radiation field described in terms of massless extremals (topological light rays). Electric field would generate acceleration in the direct of the flux tube and could excite Becker currents which would give rise to biological effects - healing of wound in the simplest case. The proposal has been that this process gives rise to what could be seen as a loading of metabolic batteries.

The combination of this view with the notion of cyclotron BE condensate leads to a slightly more complex picture. Radiation field can excite single boson states both in transversal and longitudinal degrees of freedom. Transversal ones correspond to cyclotron states with energies $E_{c,n} = (n + 1/2)E_c$, $E_c = \hbar qB/m$ and the energies of excitations are of form nE_c. Longitudinal degrees of freedom correspond to a particle in 1-D box -possibly in presence of longitudinal electric field: a simple model for the states was derived in the model for Becker's DC currents.

In the absence of longitudinal electric field the energy spectrum is $E_n = n^2 E_0$, $E_0 = \hbar^2 \pi^2 / 2mL^2$, L the length of the flux tube. Longitudinal excitations correspond to energies $(n_f - n_i)^2 E_0$ and would classically correspond to the acceleration in the electric field component parallel to the flux tube giving rise to Becker currents. For both excitations negentropically entangled states result very naturally as superpositions of single particle excitations and possibly also multi-particle excitations. Both incoming photons and liberation of metabolic energy quantum as photon can induce the excitation.

One could reinterpret the idea about universal metabolic energy quanta by interpreting them as increments of longitudinal energies at flux tube. For the excitation $n = 1 \rightarrow 2$ the energy would be $3\hbar^2 \pi^2 / 2mL^2$ which is same as zero point kinetic energy for a particle in 3-D box of side L. Quantitative prediction is therefore same as that of the original model. One can of course consider also the original option that the transfer of particles from the flux tube to a larger space-time sheet indeed liberates metabolic energy.

Let us now try to weave these ideas to an internally consistent picture. It is perhaps best to proceed by making questions.

1. Could one assign negentropic entanglement with high energy phosphate bond? If so, the period of negentropic entanglement (having Orch OR as a counterpart) would correspond to the presence of ATP and the end of this period to $ATP \rightarrow ADP$. I have considered this possibility earlier. The problem is that it is difficult to understand how negentropic entanglement could be assigned simultaneously both to ATP and to the magnetic flux tube whose length and thickness are proportional to $\hbar$ and therefore varies. One should treat ATP and flux tube as single basic structure and this does not sound convincing since the scales of flux tubes are expected to be much longer than the size scale of ATP molecule. Therefore there are two options.

   (a) ATP is just what it is believed to be: provider of metabolic energy only. One can leave also open the question whether high energy phosphate bond can be interpreted in terms of zero point kinetic energy or not.

   (b) ATP carries both metabolic energy and negentropic entanglement assignable to the phosphate bond and metabolic energy corresponds to zero point kinetic energy difference. In $ATP \rightarrow ADP$ a possibly dark photon or photons are emitted and is absorbed by a magnetic flux tube containing cyclotron Bose-Einstein condensate and the resulting de-localized single particle excitation as quantum superposition of various single particle excitations carries negentropic entanglement in the length scale associated with the magnetic flux tube, which can be much longer. Even several flux tubes could be excited simultaneously. This would regenerate long range negentropic entanglement stable under NMP. Transfer of negentropic entanglement would be in question.

2. Could the non-local excitations of cyclotron Bose-Einstein condensates by large $\hbar$ photon give rise to the negentropically entangled states? Excitation of cyclotron BE condensate requires energy so that metabolic energy is required. ATP could provide this energy. Cyclotron energy

quantum is given by $E_c = \hbar q B/m$, q and m are charged and mass of the boson. As already found, the energy of boson is sum of two contributions: energy $E_n \propto n^2$ associated with free longitudinal motion and magnetic energy $E_{c,n} \propto n + 1/2$. Longitudinal excitations could be assigned to the generation of Becker currents. This proposal would integrate metabolism, negentropy generation, and quantum like behavior of ELF em fields in living matter to single picture.

3. Could it be that ATP - instead of being a carrier of negentropic entanglement as suggested earlier - only provides the metabolic energy quantum transformed to cyclotron energy quantum or longitudinal energy quantum when negentropic entanglement is generated by exciting the cyclotron BE condensate? Or could ATP carry both metabolic energy and negentropic entanglement and both of them are transferred to the magnetic flux tube in ATP$\to$ ADP process?

   (a) Cyclotron energies are quite too small for this to make sense for the ordinary value of Planck constant. The nominal value of the metabolic energy quantum is $E_0 = 0.5$ eV which by $E_0 = h_0 f_0$ corresponds to frequency $f_0 = 5 \times 10^{13}$ Hz in near infrared. The value of electron's cyclotron frequency in the endogenous magnetic field $B_{end} = .2 \times 10^{-4}$ Tesla postulated to explain the effects of ELF em fields on vertebrate brain is $f_{c,e} \simeq 6 \times 10^5$ Hz. If metabolic energy quantum is to excite cyclotron state $(n \to n+1)$, one must have $E_c = E_0$.

   Even for electron E_c is much below E_0 small for $B = B_{end}$ and $\hbar = \hbar_0$. One can however scale both B from B_{end} and $\hbar$ from $\hbar_0$. Requiring $E_c(\hbar, B) = E_0$ and using $E_c = hf$ gives $f_{ce}/f_0 = r_1 r$, $r_1 = \frac{B}{B_{end}}$ and $r = \frac{\hbar}{\hbar_0}$, where $\hbar_0$ denotes the standard value of Planck constant. This gives $r_1 r \simeq (5/6) \times 10^8$.

   (b) There are many ways to achieve the desired upwards scaling of cyclotron energies. Magnetic flux quantization gives further constraints. One could require that magnetic flux is quantized, and that for $\hbar = \hbar_0$ the flux quantum has radius of order $L(151)$ (1 nm, cell membrane thickness) corresponding to the thickness of a flux tube assignable to single DNA nucleotide.

   The radius of flux quantum corresponds to the magnetic length $r_B = \sqrt{\hbar q B}$. In the scaling $B_{end} \to 1$ Tesla $(r_1 = 2.5 \times 10^4)$, magnetic length scales as $r_B \simeq 2.5$ μm $\to 11$ nm. From the condition $r_1 r = (5/6) \times 10^8$ one has for the scaling of Planck constant $r \sim 3.3 \times 10^3$. The scaling of the flux tubes length of $L(151)$ would give flux tube length of order 3×10 μm, which corresponds to cell size so that a flux tube connecting DNA and cell membrane could be in question. Note that the scaling of $\hbar$ does not affect zero point kinetic energy in the longitudinal direction since L scales as $\hbar$.

   (c) For flux tube length $L(151)$ and for $\hbar = \hbar_0$ the energy of the lowest longitudinal excitation is same order of magnitude as metabolic energy quantum so that the excitation of longitudinal states could be in key role in the generation of Becker's currents. There is evidence about non-local excitations of electrons in photosynthesis, [I34], which suggests that the longitudinal energy excitation could indeed play the role of fundamental metabolic energy quantum transferred to the energy of high energy phosphate bond of ATP. This interpretation leaves open the structure of high energy phosphate bond and there is no absolute need to assign zero point kinetic energy with it.

   Longitudinal energies are negligible, one must require flux tube length to be considerably longer than $L(151)$ for the ordinary value of $\hbar$. Longitudinal energies are significant only for electron for given flux tube length. Indeed, Becker currents are known to be carried by electrons.

   (d) If one allows ionic Bose Einstein condensates the value of Planck constant must be scaled up by the mass ratio m_I/m_e, where m_I and m_e are the masses of ion and electron. For proton this would give scaling ratio $r = 2^{11}$ and one would end up with the hierarchy of Planck constants coming as powers of 2^{11} suggests years ago. What is remarkable that in cyclotron degrees of freedom also protons and ions can play a signification role: the quantal effects of ELF em fields on vertebrate brain suggest that this is the case.

4. What happens if one has just electrons rather than Cooper pairs? In both transversal and longitudinal degrees of freedom one would have the analog of Fermi sphere with electron states filled up to some maximum values integers characterizing cyclotron energy and longitudinal momentum. Transitions induce also now negentropic entanglement. For cyclotron states the energy increment would be E_c so that basic metabolic energy quantum can induce the transitions. In longitudinal degrees of freedom the minimal energy increment would be $(2N+1)E_0$, where N characterizes the populated state with maximal longitudinal momentum. This energy should be equal to the metabolic energy quantum. This can be arranged but is not so natural. Experimental work is sooner or later bound to reveal whether electrons or their Cooper pairs are in question.

The option developed above is perhaps the most elegant found hitherto: it would raise the BE condensates of electronic and ionic Cooper pairs in a special position, it would lead to an explicit proposal for what negentropic entanglement is at the level of flux tubes, and in minimal form it would require no modification of the ideas related to ATP, even the standard view about ATP can be kept. Also the original hypothesis that ATP carries metabolic energy as zero point kinetic energy makes sense and also ATP could carry negentropic entanglement.

This view suggests that electronic cyclotron BE condensates are essential also for the understanding of photosynthesis. The absorption of dark photon would generate a non-local excitation of BE condensate of electron Cooper pairs - also a negentropically entangled state. The energy gain in this process could be also interpreted as a fundamental metabolic energy quantum - the interpretation is to some degree a matter of taste- and the subsequent steps in photosynthesis would only take care of the storage of the energy transferred eventually to ATP. Also chemical storage could be storage of negentropic entanglement. The metabolic energy liberated in ATP$\rightarrow$ ADP could be realized universally as IR dark photon absorbed by cyclotron BE condensate at magnetic flux tube so that dark photon beams would become the key actors of metabolism and negentropy generation. Note that a maximal negentropy gain is obtained if the number of Cooper pairs in the condensate is power of prime. Relatively small primes in the scale defined by the p-adic length scales assignable to elementary particles would be in question.

2.3.3 Pessimistic Generalization Of The Second Law Of Thermodynamics

The possibility of negentropic entanglement raises the question about the fate of the second law of thermodynamics. The proposal for a generalization of the second law of thermodynamics (see chapter *Negentropy Maximization Principle* (see `http://tinyurl.com/yd3mly5m`) based on the most pessimistic vision is that entropy indeed increases also when negentropic entanglement is generated in state function reduction. If the generation of negentropic entanglement is accompanied by a compensating entropic entanglement, how it is generated? Or is the maximally pessimistic generalization really necessary? Is it implied automatically in time scales longer than the characteristic time scale associated with the causal diamonds serving as the basic correlates for conscious selves. One must apply ensemble description in these time scales: does the non-determinism of quantum jump imply second law at the level of ensemble automatically. If this argument is correct, second law would cease to hold in time scales than that characterizing the relevant causal diamond (CD). based on the most pessimistic vision is that entropy indeed increases also when negentropic entanglement is generated in state function reduction. If the generation of negentropic entanglement is accompanied by a compensating entropic entanglement, how it is generated? Or is the maximally pessimistic generalization really necessary? Is it implied automatically in time scales longer than the characteristic time scale associated with the causal diamonds serving as the basic correlates for conscious selves. One must apply ensemble description in these time scales: does the non-determinism of quantum jump imply second law at the level of ensemble automatically. If this argument is correct, second law would cease to hold in time scales than that characterizing the relevant CD.

2.3.4   How To Understand Differentiation And De-Differentiation?

Differentiation and de-differentiation are fundamental processes in biology. Differentiation means specialization and more restricted gene expression and de-differentiation a reversal of this process. De-differentiation to the stem cell state takes place in healing of wounds and is induced by Becker's DC currents. Note that cancer cells are de-differentiated cells but Becker currents induce a further de-differentiation making them omnipotent.

De-differentiation and differentiation are strongly time-irreversible processes. Could differentiation and de-differentiation be seen as time reversals of each other and correspond to state function reductions at opposite boundaries of CD? De-differentiation would mean change of geometric arrow of time but basically a dissipative process would be in question.

The following argument based on purely entropic entanglement shows that this view cannot be correct.

1. There are two ways to see arrow of time corresponding to embedding space level and space-time level. The arrow of geometric time alternates only at the level of embedding space at space-time level alone it does not if irreversibility of quantum dynamics has space-time correlates as quantum classical correspondence requires. Space-time surface is not able to detect its own effective folding forth and back in time in the embedding space and the internal arrow of time remains the same. CD is able to detect the embedding space arrow of time for its sub-CD: . sub-CD seems to develop in reverse direction of geometric time. Dissipation occurs always in subjective time so that second law remains true.

2. Suppose that it makes sense to think that CD scans given sub-CDs again and again in time direction, which corresponds to its own arrow of geometric time. Suppose for definiteness that the scale of sub-CD is 1 year. CD observes evolution of sub-CD from 1 to 2 years then from 3 to 2 years, then from 5 to 4 years. Ageing occurs on the average. System would get 2 years older in sudden steps at both boundaries. The sudden agings by 2 years are compensated by 1 year of apparent rejuvenation between state function reductions. The interpretation as dedifferentiation is not possible. For instance, return to omnipotent stem cell stage is not possible for differentiated cells.

What is lacking is the notion of negentropic entanglement. Illness is a loss of negentropic entanglement and healing its regeneration. Aging is a loss of negentropic entanglement and de-differentiation identified as rejuvenation is regeneration of negentropic resources.

1. De-differentiation must involve a generation of negentropic entanglement defining the fundamental step in rejuvenation. Ageing is due to to state function reductions destroying entanglement. Negentropically entangled states can be however stable under NMP and NMP can even force the reversal of ageing.

2. At the level of basic metabolism generation of ATP accompanies the generation of negentropic entanglement and its transformation to ADP to its disappearance. The creation of ATP would be fundamental process of rejuvenation, and ATP could be seen as elixir of youth at the molecular level. The analogy between ATP-ADP cycle and Karma's cycle is also rather precise. This picture conforms also with the model for healing currents as a tool to generate metabolic energy, ATP, and negentropic entanglement.

2.4   Exotic Charge Transfer Between Cell Interior And Exterior As Fundamental Control Mechanism

The notions of ionic channels and pumps associated with the cell membrane are central for the standard cell biology [I128]. There are however puzzling observations challenging this dogma and suggesting that the currents between cell interior and exterior have quantum nature and are universal in the sense that they not depend on the cell membrane at all [I96, I64, I44, I137, I62]. One of the pioneers in the field has been Gilbert Ling [I96], who has devoted for more than three decades to the problem, developed ingenious experiments, and written several books about

the topic. The introduction of the book [I91]) gives an excellent layman summary about the paradoxical experimental results.

It was a pleasant surprise to find that these experimental findings give direct support for the existence of an exotic charge transfer between cell interior and exterior.

Ionic supra currents and Josephson currents or the exchange of exotic W bosons could be in question. For the first option, the experimental data led to a model for cell homeostasis as a flow equilibrium in which very small densities of super-conducting ions (also molecular ions) and ionic supercurrents at cellular and other super-conducting space-time sheets dictate the corresponding densities at the atomic space-time sheets. Z^0 super-conductivity possible for almost vacuum extremals in principle allows to generalize the model also to the control of the densities of neural atoms and molecules at atomic space-time sheets.

This control mechanism need not be the only one. Magnetic flux tubes serving as colored braid strands connecting different bio-molecules in highly selective manner and phase transitions reducing or increasing $\hbar$ could explain the mysterious precision of bio-catalysis as how the prebiotic evolution has led to the known biology [K5]. Magnetic flux tubes could also act as Josephson junctions between widely separated structures.

2.4.1 Strange Behavior Of The Intracellular Water

The basic strange feature of cellular interior is related to its gelatinous nature and is in fact familiar for everyone. Although 80 percent of hamburger is water, it is extremely difficult to extract this water out. Ling [I64] has demonstrated this at cellular level by using a centrifuge and cells for which cell membrane is cut open: centrifugal accelerations as high as 1000 g fail to induce the separation of the intracellular water.

The assumption that cytoplasm behaves like gel explains these findings. Egg is very familiar example of gel phase so that this proposal could have been made already by the pioneers. The dipolar nature of bio-molecules and induced polarization are basis prerequisites for the formation of gels. Ling raises the cohesion between water and protein molecules caused by electric dipole forces as a fundamental principle and calls this principle association-induction hypothesis [I96]. This cohesion gives rise to liquid [F6] [D4] like structure of water implying among other things layered structures and internal electric fields orthogonal to the plane of the layers [I112, I102, I96] . For instance, cell membranes can be understood as resulting from the self-organization of liquid crystals [K27]. The fundamental importance of electret nature of biomatter was also realized by Fröhlich [J80] and led him to suggest that macroscopic quantum phases of electric dipoles might be possible. This concept, which is in central role in many theories of quantum consciousness, has not been established empirically.

2.4.2 Are Channels And Pumps Really There?

Standard neurophysiology relies strongly on the concepts of what might be called hydro-electro-chemistry. The development of the theory has occurred through gradual improvements saving the existing theory.

The development began from the basic observation that cells are stable gelatinous entities not mixing with the surrounding water. This led to the hypothesis that cell membrane takes care that the contents of the cell do not mix with the cell exterior. It was however soon found that cell membrane allows some ions to flow through. The interaction between theory and experiment led gradually to the notions of ion channel and ion pump, which are still central for the standard paradigm of the cell [I128]. Note that also "electric pump" taking care that membrane potential is preserved, is needed.

These notions developed gradually during the period when cell was seen as a bag containing water and a mixture of various biochemicals. If cell biology would have started to develop during the latter half of this century and after the discovery of DNA, cell as a computer metaphor might have led to a quite different conceptualization for what happens in the vicinity of the cell membrane. Also the notion of liquid crystals [D4] would have probably led to different ideas about how homeostasis between cell interior and exterior is realized [I112, I102, I96].

For me it was quite a surprise to find that pump-channel paradigm is not at all so well-established as I had believed as an innocent and ignorant outsider. The first chapter of the

book "Cells, Gels and the Engines of Life" of Gerald Pollack [I91] provides a summary about the experimental paradoxes (the interested reader can find the first chapter of this book from web).

The standard theoretical picture about cell is based on the observation that cell exterior and interior are in a relative non-equilibrium. The measured concentrations of various atomic ions and organic molecules are in general different in the interior and exterior and cell membrane seems to behave like a semi-permeable membrane. There is also a very strong electric field over the cell membrane. In standard approach, which emerged around 1940, one can understand the situation by assuming that there are cell membrane pumps pumping ions from cell interior to exterior or vice versa and channels through which the ions can leak back. Quite a many candidates for proteins which seem to function like pump and channel proteins have been identified: even a pump protein for water [I91] ! This does not however prove that pumping and channelling is the main function of these proteins on the case of basic biological ions or that they have anything to do with how ionic and molecular concentrations in the interior and exterior of the cell are determined. It could quite well be that in the case of basic ions pump and channel proteins are receptors involved with the transfer of information rather than charges and only effectively act as pumps and channels.

There are several serious objections of principle against the vision of cell as a bag of water containing a mixture of chemicals. Even worse, the hypothesis seems to be in conflict with experimental data.

Selectivity problem

Cell membrane is extremely selective and this leads to an inflation in the complexity of channels and pumps. The problem might be christened as a dog-door problem: the door for dog allows also cat go through it. Channels cannot be simple sieves: it is known that channels which let some ions through do not let much smaller ions through. There must be more complicated criteria than geometric size for whether the channel lets the ion go through. Quite generally, channels must be highly selective and this seems to require complicated information processing to decide which ion goes through and which not. As a consequence, the models for channels inflate in their complexity.

The only reasonable way to circumvent the problem is to assume that there is kind of binary coding of various chemical compounds but it is difficult to see how this could be achieved in the framework of the standard chemistry. The notion of fractional atom proposed in [K45] to give rise to the emergence of symbols at the level of biochemistry could however allow this kind of coding. Channels and pumps (or whatever these structures actually are) could be also generated by self-organization process when needed.

Inflation in the number of pumps and channels

Channels and pumps for atomic ions and channels and pumps for an astronomical number of organic molecules are needed. The first question is where to put all those channels and pumps? Of course, one could think that pumps and channels are constructed by the cell only when they are needed. But how does the cell know when a new pump is needed if the cell as never met the molecule in question: for instance, antibiotic or curare molecule?

To realize how weird the picture based on channels and pumps is, it is useful to imagine a hotel in which there is a door for every possible client letting only that client through but no one else. This strange hotel would have separate door for every five point five milliard humans. Alternatively, the building would be in a continual state of renovation, new doors being built and old being blocked.

There is however an TGD based objection against this slightly arrogant argument. In TGD framework cell is a self-organizing structure and it might be that there is some mechanism which forces the cell to produce these pumps and channels by self-organization. Perhaps the basic characteristic of quantum control in many-sheeted space-time is that it somehow forces this kind of miracles to occur.

Why pumping does not stop when metabolism stops?

One can also wonder how metabolism is able to provide the needed energy to this continual construction of pumps and channels and also do the pumping. For instance, sodium pump alone is estimated to take 45-50 per cent of the cell's metabolic energy supply. Ling has studied the viability

of the notion of the ionic pump experimentally [I96] by exposing cell to a coctail of metabolic poisons and depriving it from oxygen: this should stop the metabolic activities of the cell and stop also the pumping. Rather remarkably, nothing happened to the concentration gradients! Presumably this is the case also for the membrane potential so that also the notion of metabolically driven electrostatic pumps seems to fail. Of course, some metabolism is needed to keep the equilibrium but the mechanism does not seem to be a molecular mechanism and somehow manages to use extremely small amount of metabolic energy.

How it is possible that ionic currents through silicon rubber membrane are similar to those through cell membrane?

A crucial verification of the channel concept was thought to come in the experiment of Neher and Sakmann [I138] (which led to a Nobel prize). The ingenious experimental arrangement was following. A patch of membrane is sucked from the cell and remains stuck on the micropipet orifice. A steady voltage is applied over the patch of the membrane and the resulting current is measured. It was found that the current consists of discrete pulses in consistency with the assumption that a genuine quantum level current is in question. The observation was taken as a direct evidence for the postulate that the ionic currents through the cell membrane flow through ionic channels.

The later experiments of Fred Sachs [I137] however yielded a complete surprise. Sachs found that when the patch of the cell membrane was replaced by a patch of silicon rubber, the discrete currents did not disappear: they remained essentially indistinguishable from cell membrane currents! Even more surprisingly, the silicon rubber membrane showed ion-selectivity features, which were essentially same as those of the cell membrane! Also the currents through synthetic polymer filters [I62] were found to have essentially similar properties: as if ion selectivity, reversal potential, and ionic gating would not depend at all on the structure of the membrane and were more or less universal properties. Also experiments with pure lipid-layer membranes [I44] containing no channel proteins demonstrated that the basic features – including step conductance changes, flickering, ion selectivity, and in-activation– characterized also cell membranes containing no ionic channels.

The in-escapable conclusion forced by these results seems to be that the existing 60-year old paradigm is somehow wrong. Ionic currents and the their properties seem to be universal and depend only on very weakly on the properties of the membrane. This conclusion need not apply to the currents of polar molecules for which genetically coded pump and channel proteins certainly exists. Neither does it imply that pumps and channels could not be used to achieve a more efficient transfer of ions. Pump - and channel proteins seem to be a well-established notion and TGD approach suggests that they serve as Josephson junctions.

This however requires a generalization of the ordinary thermodynamical approach to cell membrane by starting from zero energy ontology and replacing Boltzmann weight with the complex square roots. Chemical potentials giving dominant part to the change of energy as it goes through cell membrane is replaced with the difference of cyclotron energy which is in visible and UV range from the condition that dark EEG photons have energies of bio-photons [K44]. One ends up with a generalization of Josephson junction: the generalized Josephson energy includes besides Coulombic energy difference also the cyclotron energy difference. Dark cyclotron contribution raises the energy scale of .05-.1 eV associated with cell membrane to .5-10 eVs and one can understand the nominal value .5 eV of metabolic energy currency.

2.4.3   Cytoplasm As Gel

The solution to the above described anomalies proposed by Pollack is that cytoplasm is gel phase [I91]. Pollack describes in detail various aspects of cytoplasm as a gel phase and here only short summary can be given.

1. Cytoplasm can be regarded as a network consisting of cross-linked negatively charged proteins. Water is condensed around the proteins to form structured water. If protein is hydrophilic, water self-organizes around it as a multilayered structure: the number of molecular layers can as high as 600 and the thickness of the layered structure is a considerable fraction of micrometer. If the protein is hydrophobic, water forms another structured phase known

as clathrate water: in this case the number of hydrogen bonds between water atoms is large. These phases can be regarded as intermediate between ice and water. Also ordinary ions have this kind of layered structure around them. Chemical cross-links tend to be stable with heat, pH, and solvent composition whereas physical cross-links formed by intermolecular interactions are sensitive to environmental interactions and are of special interest from the point of view of phase transitions.

2. Pollack proposes that the formation of polymers takes place in an environment containing layered water for the simple reason that monomers cannot diffuse to the layered water so that the probability of association with the end of the growing polymer increases.

3. Cell interior is populated by micro-tubules, various filamentary structures, and the so called micro-trabecular matrix. Micro-trabecular network divides cell into a compartments in such a manner that the typical distance between two proteins in water is about 5 nm: this corresponds to the p-adic length scale $L(149)$, the thickness of the lipid layer of cell membrane. This is probably not an accident and the micro-trabecular network might be closely involved with the highly folded network of intracellular membranes. There would be a layer of thickness of about 6 water molecules per given protein surface so that a dominating portion of intracellular water could be structured.

4. The layered water has several tell-tale signatures that have been observed in gels. It freezes at much lower temperature than ordinary water; various relaxation times are shorter since the energy transfer to the water lattice occurs faster than to non-structure water; the diffusion rates of particles into the structured water are much slower than to ordinary water by entropy argument; a simple geometric argument tells that the larger the size of the hydrated ion the lower the diffusion rate; strong gradients of ionic concentrations can form in gel phase as has been observed.

   The identification of the cytoplasm as a gel has profound implications for the standard views about cell.

1. The original motivation for postulating semipermeable cell membrane, channels, and pumps was the need to hinder the diffusion of various ions between cell interior and exterior taking place if cytoplasm is ordinary water into which molecules are dissolved. If cytoplasm is in gel phase, cell membrane need not perform pumping and channeling anymore except perhaps in situations involving the formation of a local sol phase. This raises the question about the proper functions of the cell membrane.

2. It is possible to drill to cell membrane holes with size of order 1 μm without an appreciable effect on the functioning of the cell and also show that these holes remain as such for long periods of time [I91]. It is also possible to splice cells into pieces continuing to function for days. That K^+ flux through cell membrane does not change when lipids are partially removed. These findings force to ask whether the assumption about the continuity of the cell membrane might be too strong [I91]. Electron micrographs however demonstrate the presence of the bi-layered structure. What is intriguing that this structure is seen even in the absence of lipid layers. In TGD framework this paradoxical finding might be understood in terms of a presence of space-time sheets corresponding to p-adic length scales $L(k)$, $k = 149, 151$ as vacuum structures predicted also by TGD inspired model of high T_c super-conductivity [K25].

3. There is also the strange finding that water flux through cell membrane is much higher than the flux through isolate lipid bi-layer as if some unidentified channels were present. In TGD framework this might be seen as an evidence for the presence of (wormhole) magnetic flux tubes as carriers of water molecules.

4. The fundamental assumptions about ionic equilibrium must be reconsidered, and the Hodkin-Huxley model for the generation of nerve pulse becomes more or less obsolete. Indeed, it has been found that action potentials can be generated even in absence of Na^+ and K^+ ions playing a key role in Hodkin-Huxley model. Rather remarkably, the high concentration of K^+ ions and low concentration of Na_+ ions in cytoplasm could be understood on basis

of gel property only. Also new view about cell (note membrane-!) potential emerges. The standard paradigm states that the resting potential is over the cell membrane. Potentials of same order of magnitude have been however seen in de-membraned cells (50 mV in slight excess of action potential and critical potential), colloidal suspensions, and gels which suggest that larger part of cell than mere cell membrane is involved with the generation of the action potential and one should thus speak of cell potential instead of membrane potential.

5. Pollack suggests that the phase transitions of the gel phase make possible to realize various functions at molecular and cellular level and represents empirical evidence for the phase transition like aspects assigned to these functions including sensitivity to various factors such as pH, temperature, chemical environment, electromagnetic fields, mechanical forces, etc... and the threshold behavior [I91]. Also the responses are typical for phase transitions in that they involve dramatic changes in volume, shape, di-electric constant, etc.. With these motivations Pollack discusses phase transition based models for contraction, motility, secretion, transport or molecules, organized flow of particles during cell division, cell locomotion, contraction of muscle, generation of action potentials, etc.. For instance, the transport of bio-molecules along micro-tubule could involve propagating gel-sol-gel phase transition meaning also propagating melting of the layered water around micro-tubule.

6. Divalent ions, such as Mg^{+2} and Ca^{+2} can act as cross links between negatively charged proteins binding them to form networks. Monovalent ions cannot do this. Peripheral cytoskeleton is this kind of network consisting of micro-tubules and actin molecules cross-linked - according to Pollack- by Ca^{+2} ions. On the other hand, it is known that Mg^{+2} (Ca^{+2}) ions dominate in the cell interior (exterior) and that the presence of Ca^{+2} ions in the cell exterior is crucial the for generation of nerve pulse. The influx of Na^+ ions having higher affinity to proteins can induce a phase transition to sol-like phase. Pollack suggests a model of nerve pulse based on this mechanism of gel-sol phase transition for peripheral cytoskeleton: this model does not actually explain why Ca^{+2} ions in the exterior of axon are necessary.

2.4.4   TGD Based Vision Inspired By The Findings

The vision about dark matter and the model of nerve pulse formulated in terms of Josephson currents brings an additional perspective to the role of pumps and channels and allows to achieve harmony with the standard views about their role.

1. In long length scales visible matter forms roughly 5 per cent of the total amount of matter. In TGD Universe the dark matter would correspond to matter with large Planck constant including dark variants of ordinary elementary particles. In living matter situation could be the same and visible matter could form only a small part of the living matter. Dark matter would be however visible in the sense that it would interact with visible matter via classical electromagnetic fields and photon exchanges with photons suffering Planck constant changing phase transition. Hence one can consider the possibility that most of the biologically important ions and perhaps even molecules reside at the magnetic flux quanta in large $\hbar$ phase.

2. Bosonic ions could form Bose-Einstein condensates at the flux tubes in which case supra currents flowing without any dissipation would be possible. The model for high T_c super-conductivity suggests that only electronic and protonic super-conductivity are possible at room temperature. If so, Cooper pairs of fermionic ions are excluded. New nuclear physics predicted by TGD could however come in rescue here. The TGD based model for atomic nucleus assumes that nuclei are strings of nucleons connected by color bonds having quark and antiquark at their ends. Also charged color bonds are possible and this means the existence of nuclei with anomalous charge. This makes possible bosonic variants of fermionic ions with different mass number and it would be interesting to check whether biological important ions like Na^+, Cl^-, and K^+ might actually correspond to this kind of exotic ions.

This leads to the following TGD inspired vision about cell as a gel.

1. DNA as TQC hypothesis and cell membrane as sensory receptor provide possible candidates for the actual functions of the cell membrane and ionic channels and pumps could act as kind of receptors. That standard physics is able to describe gel phase is of course a mere belief and (wormhole) magnetic flux tubes connecting various molecules (DNA, RNA, amino-acids, biologically important ions) would be "new physics" cross-links could explain the strong correlations between distant molecules of the gel phase.

2. Dark ionic currents are quantal currents. If the dark ions flow along magnetic or wormhole magnetic flux tubes connecting cell interior and exterior, their currents through cell membrane would be same as through an artificial membrane.

3. Pumps and channels could serve the role of sensory receptors by allowing to take samples about chemical environment. One cannot exclude the possibility that proteins act as pumps and channels in sol phase if magnetic flux tubes are absent in this phase since also in TGD Universe homeostasis and its control at the level of visible matter in sol phase might requires them. The metabolic energy needed for this purpose would be however dramatically smaller and a reliable estimate for this would allow an estimate of the portion of dark matter in living systems.

4. Quantum criticality suggests that the phase transitions for the gel phase are induced by quantum phase transitions changing the value of Planck constant for magnetic flux tubes and inducing the change of the length of the flux tube. Macroscopic quantum coherence would explain the observed co-operativity aspect of the phase transitions. Concerning loco-motion and transport mountain climbing using pickaxe and rope inspires a guess for a general mechanism. For instance, a packet of molecules moving along actin molecule or a molecule carrying a cargo along micro-tubule could repeat a simple basic step in which a magnetic flux tube with large $\hbar$ is shot along the direction of the electric field along micro-tubule and stuck to a rachet followed by a phase transition reducing the value of $\hbar$ and shortening the flux tube and forcing the cargo to move forward. The metabolic energy might be provided by the micro-tubule rather than molecular motor.

5. The reconnection of flux tubes would be a second phase transition of this kind. This phase transition could lead from a phase in phase proteins are unfolded with flux tubes connecting amino-acids to water molecules and thus possessing a large volume of layered water around them to a phase in which they become folded and flux tubes connect amino-acids to each other in the interior of protein. The phase transition could be associated with the contraction of connecting filaments of muscle cell. The phase transitions are also seen in "artificial protein" gels used for drug delivery applications, and are built from polymers arranged in alpha helices, beta sheets and common protein motifs [I91]. If wormhole magnetic flux are taken are taken as a basic prerequisite of life, one must ask whether these "artificial proteins" represent artificial life.

6. The fact that cytoskeleton rather than only cell membrane is involved with the generation of action potential conforms with the idea that nerve pulse propagating along axon involves also axonal micro-tubules and that Josephson currents between axon and micro-tubules are involved in the process.

7. Di-valent ions (Ca^{+2} ions according to Pollack) serve as cross links in the peripheral cy-toskeleton. The influx of monovalent ions from the exterior of axon induces gel-sol phase transition replacing di-valent ions with monovalent ions. One can consider two models.

   (a) The minimal assumption is that this phase transition is induced $\hbar$ increasing phase transition the flow of the monovalent ions like Na^+ from the cell exterior along the magnetic flux tubes connecting axonal interior and interior. Suppose that in the original situation the flux tubes end to axonal membrane (this is not the only possibility, they could also end to Ca^{+2} ions). The flux tubes extending to the axonal exterior could result by $\hbar$ increasing phase transition increasing the length of the flux tubes connecting peripheral cytoskeleton to the axonal membrane so that they extend to the exterior of axon. This option is rather elegant since gel-sol phase transition itself can be understood

in terms of "standard chemistry". In this model the very slow diffusion rate of the ions to gel phase would have explanation in terms of new physics involving dark matter and (wormhole) magnetic flux tubes.

(b) One can consider also an option in which divalent ions such as Ca^{+2} or Mg^{+2} are connected by two flux tubes to amino-acids of two negatively charged proteins whereas monovalent biological ions like Na^+ would have single flux tube of this kind and could not act as cross links. In the phase transitions removing the cross links the replacement of divalent ion with two monovalent positively charged ions would take place. If one believes in standard chemistry, Na^+ ions would flow in automatically. First the increase of Planck constant would induce the lengthening of the magnetic flux tubes and thus the expansion of the gel phase making possible the influx of monovalent ions. If Na^+ ions are dark, flux tubes connecting peripheral cytoskeleton to the axonal exterior are required and the mechanism of option i) is also needed.

8. The mechanisms i) and ii) could be fused to a single one. The hint comes from the presence of Ca^{+2} ions in the exterior of axon is necessary for the generation of action potential. The simplest possibility is that the flux tubes connecting proteins to intracellular Ca^{+2} cross links in gel phase connects them after the length increasing phase transition to extracellular Ca^{+2} ions and Na^+ ions flow along these flux tubes.

9. The increase of the Planck constant would induce the expansion of the peripheral cytoskeleton making possible the inflow of Na^+ ions, and divalent ions binding negatively charged actin molecules to a network would be replaced with inflowing Na^+ ions. After this a reverse phase transition would occur. Both phase transitions could be induced by a quantal control signal (Josephson current) inducing quantum criticality and a change of Planck constant.

10. A propagating Ca^{+2} wave inducing the gel-sol-gel phase transition of peripheral cytoskeleton would accompany nerve pulse. Quite generally, Ca^{+2} waves are known to play a fundamental role in living matter as kind of biological rhythms. Irrespective of whether one believes option a) or b), this might relate to the cross-linking by flux tubes and gel-sol-gel phase transitions induce by phase transitions increasing Planck constant temporarily. The velocities and oscillation periods of Ca^{+2} waves vary in an extremely wide range: this can be understood if the flux tubes involved correspond to a very wide spectrum of Planck constant.

Besides basic ions cell membrane is non-permeable to various polar molecules such as the basic building bricks of DNA and amino-acids. The safest assumption is that genetically coded pump and channel proteins make possible the transfer. One must of course consider the possibility that channels and pumps are used to make the transfer of basic ions more effective. Taking this into account, the proposed vision does not differ so radically from the standard one as one might think first and only the model for nerve pulse generation must be modified radically.

To sum up, the strange discoveries about the behavior of cell membrane provide direct experimental evidence for the presence of dark matter in living systems, for the prediction that it interacts with ordinary matter via classical electromagnetic fields, and for the assumption that it does not dissipate appreciably and could therefore have large value of $\hbar$ and form macroscopic quantum phases.

2.5 Quantum Model For The Direct Currents Of Becker

Robert Becker [J24] proposed on basis of his experimental work that living matter behaves as a semiconductor in a wide range of length scales ranging from brain scale to the scale of entire body. Direct currents flowing only in preferred direction would be essential for the functioning of living manner in this framework.

One of the basic ideas of TGD inspired theory of living matter is that various currents, even ionic currents, are quantal currents. The first possibility is that they are Josephson currents associated with Josephson junctions but already this assumption more or less implies also quantal versions of direct currents.

TGD inspired model for nerve pulse assumes that ionic currents through the cell membrane are quantal currents. If they are Josephson currents, the situation is automatically stationary and dissipation is small as various anomalies suggest. One can criticize this assumption since the Compton length of ions for the ordinary value of Planck constant is so small that magnetic flux tubes carrying the current through the membrane look rather long in this length scale. Therefore either Planck constant should be rather large or one should have a non-ohmic quantum counterpart of a direct current in the case of ions and perhaps also protons in the case of neuronal membrane: electronic and perhaps also protonic currents could be still Josephson currents. This would conform with the low dissipation rate.

In the following the results related to laser induced healing, acupuncture, and DC currents are discussed first. The obvious question is whether these direct currents are actually supracurrents and whether they could be universal in living matter. A TGD inspired model for quantal direct currents is proposed and its possible implications for the model of nerve pulse are discussed.

Whether the model for quantum direct currents is consistent with the proposed vacuum extremal property of the cell membrane remains an open question but both options explain the special role of Ca^{++} currents and current of Na^+ Cooper pairs in the generation of nerve pulse as in would take place in TGD Universe. In fact, it is not clear what one exactly means with the vacuum extremal property of cell membrane. Many-sheeted space-time (see **Fig.** `http://tgdtheory.fi/appfigures/manysheeted.jpg` or **Fig.** 9 in the appendix of this book) allows to consider space-time sheets which can be both almost vacuum extremals and far from vacuum extremals. Also space-time sheets for which Planck constant is so large that both electronic and protonic Josephson currents become possible. Various pumps and channels could actually correspond to magnetic flux tubes along which various ionic supra currents or even Josephson currents can flow. The condition that both electronic and protonic supra currents are possible in same length scale leads to the hierarchy of Planck constants coming approximately as powers of $m_p/m_e \simeq 2^{11}$ proposed originally as a general truth. Radiation at Josephson frequency serves as a signature for Josephson currents.

In the following a TGD inspired quantum model for the direct currents of Becker as direct quantum currents is developed and shown to be consistent with what is known about nerve pulse generation.

2.5.1   Connection Between Laser Induced Healing, Acupuncture, And Association Of DC Currents With The Healing Of Wounds

The findings of Robert Becker (the book "The Body Electric: Electromagnetism and the Foundation of Life" by Becker and Selden, which can be found from web (see `http://tinyurl.com/y8rbgebw`) [J24], meant a breakthrough in the development of bioelectromagnetics. One aspect of bioelectromagnetic phenomena was the discovery of Becker that DC currents and voltages play a pivotal role in various regeneration processes. Why this is the case is still poorly understood and Becker's book is a treasure trove for anyone ready to challenge existing dogmas. The general vision guiding Becker can be summarized by a citation from the introduction of the book.

Growth effects include the alteration of bone growth by electromagnetic energy, the restoration of partial limb regeneration in mammals by small direct currents, the inhibition of growth of implanted tumors by currents and fields, the effect upon cephalocaudal axis development in the regenerating flatworm in a polarity-dependent fashion by applied direct currents, and the production of morphological alterations in embryonic development by manipulation of the electrochemical species present in the environment. This partial list illustrates the great variety of known bioelectromagnetic phenomena.

The reported biological effects involve basic functions of living material that are under remarkably precise control by mechanisms which have, to date, escaped description in terms of biochemistry. This suggests that bioelectromagnetic phenomena are fundamental attributes of living things, ones that must have been present in the first living things. The traditional approach to biogenesis postulates that life began in an aqueous environment, with the development of complex molecules and their subsequent sequestration from the environment by membranous structures. The solid-state approach proposes an origin in complex crystalline structures that possess such properties as semiconductivity, photoconductivity, and piezoelectricity. All of the reported effects of electromagnetic forces seem to lend support to the latter hypothesis.

Observations relating to CNS

The following more quantitative findings, many of them due to Becker, are of special interest as one tries to understand the role of DC currents in TGD framework.

1. CNS and the rest of perineural tissue (tissue surrounding neurons including also glial cells) form a dipole-like structure with neural system in positive potential and perineural tissue in negative potential. There is also an electric field along the neuron in the direction of nerve pulse propagation (dendrites correspond to - and axon to +) (note that motor nerves and sensory nerves form a closed loop). Also microtubules within axon carry electric field and these fields are probably closely related by the many-sheeted variants of Gauss's and Faraday's laws implying that voltages along two different space-time sheets in contact at two points are the same in a static situation.

2. A longitudinal potential along front to back in the brain with the frontal lobes in negative potential with respect to occipital lobes and with a magnitude of few mV was discovered. The strength of the electric field correlates with the level of consciousness. As the potential becomes weaker and changes sign, consciousness is lost. Libet and Gerard observed traveling waves of potentials across the cortical layers (with speeds of about 6 m/s: TGD inspired model of nerve pulse predicts this kind of waves [K92]). Propagating potentials were also discovered in glial cells. The interpretation was in terms of electrical currents.

3. It was found that brain injury generated positive polarization so that the neurons ceased to function in an area much larger than the area of injury. Negative shifts of neuronal potentials were associated with incoming sensory stimuli and motor activity whereas sleep was associated with a positive shift. Very small voltages and currents could modulate the firing of neurons without affecting the resting potential. The "generating" potentials in sensory receptors inducing nerve pulse were found to be graded and non-propagating and the sign of the generating potential correlated with sensory input (say increase/reduction of pressure). Standard wisdom about cell membrane has difficulties in explaining these findings.

4. The natural hypothesis was that these electric fields are accompanied by DC currents. There are several experimental demonstrations for this. For instance, the deflection of assumed DC currents by an external magnetic field (Hall effect) was shown to lead to a loss of consciousness.

Observations relating to regeneration

The second class of experiments used artificial electrical currents to enhance regeneration of body parts. These currents are nowadays used in clinical practice to induce healing or retard tumor growth. Note that tissue regeneration is a genuine regeneration of an entire part of the organism rather than mere simple cell replication. Salamander limb generation is one of the most studied examples. Spontaneous regeneration becomes rare at higher evolutionary levels and for humans it occurs spontaneously only in the fractures of long bones.

1. An interesting series of experiments on Planaria, a species of simple flatworm with a primitive nervous system and simple head-to-tail axis of organization, was carried out. Electrical measurements indicated a simple head-tail dipole field. The animal had remarkable regenerative powers; it could be cut transversely into a number of segments, all of which would regenerate a new total organism. The original head-tail axis was preserved in each regenerate, with that portion nearest the original head end becoming the head of the new organism. The hypothesis was that the original head-tail electrical vector persisted in the cut segments and provided the morphological information for the regenerate. The prediction was that the reversal of the electrical gradient by exposing the cut surface to an external current source of proper orientation should produce some reversal of the head-tail gradient in the regenerate. While performing the experiment it was found found that as the current levels were increased the first response was to form a head at each end of the regenerating segment. With still further increases in the current the expected reversal of the head-tail gradient did occur, indicating that the electrical gradient which naturally existed in these animals was capable of transmitting morphological information.

2. Tissue regeneration occurs only if some minimum amount of neural tissue is present suggesting that CNS plays a role in the process although the usual neural activity is absent. The repeated needling of the stump had positive effect on regeneration and the DC current was found to be proportional to innervation. Hence needling seems to stimulate innervation or at least inducing formation of DC currents. Something like this might occur also in the case of acupuncture.

3. Regeneration involves de-differentiation of cells to form a blastema from which the regenerated tissue is formed. Quite early it was learned that carcinogens induce de-differentiation of cells because of their steric properties and by making electron transfer possible and that denervation induces tumor formation. From these findings Becker concluded that the formation of blastema could be a relatively simple process analogous to tumor growth whereas the regeneration proper is a complex self-organization process during which the control by signals from CNS are necessary and possibly realized in terms of potential waves.

4. Regeneration is possible in salamanders but not in frogs. This motivated Becker and collaborators to compare these situations. In an amputated leg of both salamander and frog the original negative potential of approximately -1 mV was raised first to a positive value of about +10 mV. In the frog it returned smoothly to its original value without regeneration. In the salamander it returned over a period of three days to the original base line and then went to a much higher negative value around -20 mV (resting potential is around -70 mV) followed by a return to the original value once regeneration had occurred. Thus the large negative potential is necessary for the regeneration and responsible for the formation of blastema. Furthermore, artificial electron current also induced regeneration also in the case of the frog, even in the denervated situation. Thus the flow of electrons to the stump seems to be necessary for the formation of blastema and the difference between salamander and frog is that frog is not able to provide the needed electronic current although positive potential is present.

5. It was also learned that a so called neuroepidermal junction (NEJ) formed in the healing process of salamander stump was responsible for the regeneration in the presence of denervation. The conclusion was that the DC voltage and electronic current relevant for regeneration could be assigned the interface between CNS and tissue rather than to the entire nerve and the regeneration seemed to be a local process, perhaps a feed of metabolic energy driving self-organization. Furthermore, NEJ seemed to make possible the flow of electrons from CNS to the stump.

6. The red blood cells of animals other than mammals are complete and thus possess nuclei. Becker and collaborators observed that red blood cells also dedifferentiated to form blastemas. Being normally in a quiescent state, they are ideal for studying de-differentiation. It was found that the electric current acted as a trigger at the level of cell membrane inducing de-differentiation reflected as an increased amount of mRNA serving as marker of gene expression. Also pulsed magnetic field was found to trigger the de-differentiation, perhaps via induced electric field. By the way, the role of the cell membrane fits nicely with the TGD inspired view about DNA-cell membrane system as topological quantum computer with magnetic flux tubes that are assumed to connect DNA and cell membrane and serve as braid strands in TGD inspired model of DNA as topological quantum computer [K5].

7. The experiments of Becker and collaborators support the identification of the charge carriers of DC currents responsible for the formation of the stump's large negative potential as electrons. The test was based on the different temperature dependence of electronic and protonic conductivities. Electronic conductivity increases with temperature and protonic conductivity decreases and an increase was observed.

Gene activation by electrostatic fields?

The basic question concerns the method of activation. The discovery of chemists Guido Ebner and Guido Schuerch [J11] raises the hope that these ideas might be more than over-active imagination and their work also provides a concrete proposal for the activation mechanism. Ebner and Schuerch

studied the effect of electrostatic fields on the growth and morphogenesis of various organisms. Germ, seeds, or eggs were placed between conducting plates creating an electric field in the range .5-2 kV/m: note that the Earth's electric field is in the range $.1 - 4$ kV/m and of the same order of magnitude.

The outcome was rather surprising and in the year 1989 their employer Ciba Geigy (now Novartis) applied for a patent "Method of enhanced fish breeding" [J11] for what is called Ciba Geigy effect. The researchers describe how fishes (trouts) develop and grow much better, if their eggs have been conditioned in an electrostatic field. The researchers also reporedt [J11] that the morphology of the fishes was altered to what seems to represent an ancient evolutionary form: this was not mentioned in the patent.

The chemists founded their own Institute of Pharmaceutical Research near Basel, where Guido Ebner applied for another very detailed patent, which was never granted. In the patent he describes the effect of electrostatic fields on several life forms (cress, wheat, corn, fern, micro-organisms, bacteria) in their early stage of development. A clear change in the morphogenesis was observed. For instance, in one example fern had all sort of leaves in single plant apparently providing a series of snapshots about the evolution of the plant. The evolutionary age of the first leaf appeared to be about 300 million years whereas the last grown-up leaf looked close to its recent form.

If one takes these finding seriously, one must consider the possibility that the exposure to an electrostatic field can activate passive genes and change the gene expression so that older morphologies are expressed. The activation of not yet existing morphologies is probably more difficult since strong consistency conditions must be satisfied (activation of program requires activation of a proper hardware). This would suggest that genome is a kind of archive also containing also older genomes even potential genomes or that topological quantum computer programs [K5] determine the morphology to a certain extent and that external conditions such as electric fields determine the self-organization patterns characterizing these programs.

It is known that the developing embryo has an electric field along the head-tail axis and that this field plays an important role in the control of growth. These fields are much weaker than the fields used in the experiment. p-Adic length scale hierarchy however predicts an entire hierarchy of electric fields and living matter is indeed known to be full of electret structures. The strength of the electric field in some p-adic length scale related to DNA might somehow serve as the selector of the evolutionary age. The recapitulation of phylogeny during ontogeny could mean a gradual shift of the activated part of both genome and "memone" (as as menetic analog of genome: for a proposal of memetic code see [K52]), perhaps assignable to topological quantum computer programs realized as braidings, and be controlled by the gradually evolving electric field strength.

The finding that led Ebner to his discovery was that it was possible to "wake up" ancient bacteria by an exposure to an electrostatic field. The interpretation would be in terms of loading of metabolic batteries. This would also suggest that in the case of primitive life forms like bacteria the electric field of the Earth has served as metabolic energy source whereas in higher life forms endogenous electric fields have taken the role of Earth's electric field.

A TGD based model for the situation

On the basis of these observations one can try to develop a unified view about the effects of laser light, acupuncture, and DC currents. It is perhaps appropriate to start with the following - somewhat leading - questions inspired by a strong background prejudice that the healing process - with control signals from CNS included - utilises the loading of many-sheeted metabolic batteries by supra currents as a basic mechanism.

The first series questions, observations, and ideas relates to the connection of DC currents with metabolism and ordinary biochemistry. The hierarchy of Planck constant is expected to be involved somehow.

1. How the DC currents relate to metabolism and ordinary biochemistry? For what purpose they are needed? The crucial point is that the energy of order 1 meV gained by electron in the electric field is much below the metabolic energy quantum and also thermal energy so that the interpretation in terms of metabolic energy quantum does not look promising. This forces to consider the possibility that the basic role of electric field is to drive electrons to

where they are needed, say wounded part of tissue in positive potential and thus attrracting electrons. Electrons are indeed needed by the electron transport cycle appearing in both photosynthesis and cell respiration since the transport cycle induces leakage of electrons due to the formation of ROS (reactive oxygen species) such as O_2^-. The purpose of electronic Becker currents would be therefore the re-establishment of metabolism.

The change of the sign of the Becker potential to positive induce a loss of electrons and reduced metabolism. This could explain why consciousness is lost when the sign of Becker potential is changed or electrons are deviated by Hall effect. Wound damages the connections of the tissue to the organism and the transfer of electrons compensating for leaked electrons is prevented since Becker potential changes sign. The regeneration induced by an artificial Becker potential of correct sign would induce healing by re-establishing the electron feed.

The crucial question concerns the role of electrons. It seems that in all situations electron flow to the damaged tissue induces healing. Why electrons generating negative potential should help in healing? The first input is TGD model [K86] [L23] for the findings of Pollack [L23] involves the connection of dark matter hierarchy $h_{eff} = n \times h$ with negentropic entanglement characterized by density matrix reducing to $n \times n$ unit matrix for entanglement matrix proportional to a unitary matrix. In infinite-dimensional case the divisor is infinite unless one uses von Neumann's hyperfinite factor of type II_1 for which the normalization factor can be taken to be unity: in the case of quantum groups this corresponds to using quantum trace instead of the ordinary one. A further input is the observation that the gravitational Planck constant h_{gr} explaining planetary Bohr quantization rules can be equal to h_{eff} in living matter for microscopic systems like elementary particles, atoms, and ions, even molecules [K109, K90].

1. Pollack's findings about fourth phase of water formed when external energy feed induces formation of negatively charged exclusion zones of water obeying stoichiometry $H_{1.5}O$ with 1/4: th of protons going to the complement of exclusion zone. Something similar might happen also now.

2. In TGD framework this process is explained as a formation dark phase of protons at the magnetic flux tubes associated with the exclusion zone with dark protons realizing genetic code so that one obtains what might be regarded as primitive primordial life form.

3. There is evidence for a huge anomalous gravimagnetic Thomson field in rotating super conductors. Thomson field is proportional to square of Planck constant h_{eff} and TGD explanation is that large h_{gr} phase is formed at gravitational flux tubes. The assumption $h_{gr} = h_{eff}$ in elementary particle and atomic scales is possible and is consistent with the hypothesis that bio-photons in visible and UV energy range correspond to decay products of dark EEG photons.

4. $\hbar_{gr}$ can be generalized to $\hbar_{em} = -Z_1 Z_2 e^2 / v_0$: v_0 would be typical rotational velocity in a system with opposite charges Z_1 and Z_2. Exclusion zone would be good example. For ATP v_0 would be rotational velocity of ATP. For exclusion zone v_0 could be rotational velocity of Cooper pairs in magnetic field associated with flux tubes or walls or rotational velocity of magnetic body. $Z_2 = -Z_1$ is natural assumption by charge neutrality.

5. In this framework the feed of electrons would increase the value of h_{eff} by increasing the negative charge associated with the analog of exclusion zone accompanying the wound and induce also a flow of dark protons to the magnetic flux tubes associated with the magnetic body of the analog of exclusion zone.

6. The DC currents would be needed because the damage of the tissue means that the $\hbar_{eff} = \hbar_{em} = Z^2 e^2 / v_0$ is reduced for a pair formed by damaged system and its complement. Healing would be essentially attempt to increase h_{eff} to its original value. The parameter Z^2 is reduced and must be increased to its original value and perhaps even to a higher value since the larger ger the value of h_{eff} is, the richer the negentropic resources of system are. The transfer of electrons to the system analogous to exclusion zone induces transfer of dark protons to the magnetic flux quanta of the magnetic body of the system. Recall that dark proton strings at flux tubes could be analogs of dark nuclei and that the model for dark

nucleons allows to identify nucleon states as counterparts of DNA, RNA, amino-acids and even tRNA. This leads to a model of prebiotic lifeforms [K53].

7. ATP synthase transforming ADP to ATP involves rotating shaft and one can ask whether the velocity parameter v_0 appearing in the expression for $\hbar_{em}$ equals to the rotation speed of the shaft. This predicts that the value of $\hbar_{em}$ to be same order as $\hbar_{eff}$ and $\hbar_{gr}$ for Earth-electron system assuming that v_0 corresponds to the rotation velocity at the surface of Earth. The assumption $h_{eff} = h_{gr} = h_{em}$ makes it possible for the gravitational and em flux tubes to reconnect.

8. The original guess was that electrons to provide energy giving rise to the formation of ATP in cell respiration and photosynthesis. Electrons themselves receive their energy either from the oxidation of molecules or from solar photons. This model is consistent with the model above since electron transport chain is crucial for cell transpiration and needs both electrons and dark protons located at the dark flux tubes associated with the exclusion zones. Dark protons would flow through the ATP synthase attached to mitochodrial membrane and liberate dark cyclotron energy if the value of the magnetic fields associated with the flux tube is different for the interior and exterior portions of the flux tube [K44, K85].

The experimental support for the role of bio-photons in living matter is accumulating and a natural question concerns their role in metabolism. In TGD framework dark photons with large value of $\hbar_{eff}$ with energy of visible photon can transform to ordinary photons of same energy with some - presumably rather small - probability, and would be interpreted as bio-photons. Could dark photons take the role of solar photons and provide in some situations energy to the electrons in the electron transport cycle? This would mean a non-conventional non-local mechanism of metabolism. The effects of laser light on tissue suggest that laser light indeed takes the role of solar light and feed energy to the electron transport cycle transforming it to the energy of high energy phosphate bond of ATP. A more detailed TGD inspired view about what might happen is discussed in [K58].

One can consider also the possibility that quantum credit card mechanism (remote metabolism) could be at work in some the situations when chemical metabolic energy sources are absent. Damaged tissue might define this kind of exceptional situation. This brings in mind the strange ability of plants suffering under-nutrition to attract insects responsible for their pollination observed by Callahan, who has also reported that plants and insects communicate using infrared light which according to his findings serves as a sensor input in insect olfaction [I32]: also in this case quantum credit card mechanism building magnetic flux tube bridges guiding the insects to the plant might be at work. The electrons which have gained 1 meV energy during travel along pairs formed by MEs and parallel magnetic flux tubes (meridians), could send negative energy dark photons with energy of order -.5 eV to gain same positive energy allowing to get over the semiconductor junction after they have arrived to the damaged tissue. These negative energy photons would be absorbed by a metabolic energy store (ATP in mitochondria transforming to ADP) in the healthy part of the organism.

$h_{eff} = h_{em}$ implies that the spectrum of bio-photons originating from dark cyclotron photons is universal having no dependence on ion mass and in visible and UV range, which is also the range for molecular excitation energies. Dark cyclotron photons decaying to bio-photons would therefore allow magnetic body to control biochemistry by resonant absorption inducing transitions of molecules.

The original model for the charging of the metabolic batteries and for effective semiconductor junction assumed that the electrons of supra current are transferred to smaller space-time sheets.

1. For ground state electrons this requires energy which is at least the difference of zero point kinetic energies of electron at the two space-time sheets. This energy should be of the order of fundamental metabolic energy quantum of about.5 eV.

For Cooper pairs of electrons the sheet should correspond to p-adic length scale of order $L_e(k_e = 149) = 10$ nm, the thickness of lipid layer of cell membrane. For single proton corresponding scale would be $L_e(k_p = 139) \simeq 2^{-12} L_e(151)$ from $m_p/2m_e \simeq 2^{10}$ and $E_{0,p}/E_{0,2e} = (2m_e/m_p) \times (L_e(k_e)/L_e(k_p))^2 = (2m_e/m_p) \times 2^{k_e - k_p} \sim 1$.

This suggests that electron Cooper pair is kicked to a smaller space-time sheet assignable to a mitochondrial lipid layer having $k_e = 149$. The larger space-time sheet could be that of cell membrane with $k = 151$. For protons the zero point kinetic energies at these space-time sheets are by a factor $2m_e/m_p$ lower and of the order of .5 meV. This happens to be of the same order of magnitude as the energy gained by proton or electron in the Becker potential. May be this is not an accident.

There is also a second intriguing quantitative coincidence. In the absence of an action potential, acetylcholine vesicles spontaneously leak into the synaptic junction and cause very small de-polarizations in the postsynaptic membrane known as miniature end plate potentials (see `http://tinyurl.com/y98zhxzh`) (mEPSP) of magnitude .5 mV. These potentials are too small to generate action potential but together they can sum up to the needed action potential. Maybe the interpretation in terms of proton kicked to lipid layer space-time sheet might make sense.

2. The re-charging mechanism should relate directly to ADP$\rightarrow$ ATP process occurring during electronic transport cycle in mitochondrial membrane. The connection with metabolism forces to ask how the formation of high energy phosphate bond in the addition of phosphate to ADP relates to the transfer of electrons to smaller space-time sheet. Somehow the energy of electrons must go to the formation of this bond: perhaps the dropping of electron back to larger space-time sheet transfers the energy to the high energy phosphate bond.

   In many-sheeted space-time particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries of space-time sheet of a given system. Also p-adic phase transition increasing the size of the space-time sheet could take place and the liberated energy would correspond to the reduction of zero point kinetic energy. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant h_{eff} so that cyclotron energy would be liberated.

3. The transfer of particles between space-time sheets with different p-adic length scales is not the only one that one can consider, and recently a more elegant mechanism has emerged [K58]. If the particles are free, a phase transition in which the p-adic prime of the space-time sheet containing particles decreases adiabatically increases the scale of kinetic energy but leaves particle quantum numbers unchanged. If the same happens for charge particles at magnetic flux tubes, similar increase of cyclotron energy scale takes place since magnetic field strength increase to conserve magnetic flux. The predictions are in good approximation the same as for the original model. If the phase transition reducing p-adic length scale is accompanied by a compensating increase of Planck constant, the size scale of space-time sheet remains unaffected but metabolic batteries are loaded. The reversal of this phase transition liberates metabolic energy. What is important that metabolic energy and negentropic entanglement (measured in terms of the value of Planck constant) are closely correlated for this mechanism. The loading/liberation of energy is also a quantum coherent process.

4. Acupuncture and the application of DC current are known to induce the generation of endorphins. Do endorphins contribute to well-being by reducing the pain? In TGD framework the deeper level interpretation of metabolism is as a provider of negentropic entanglement in turn giving rise to well-being. Are endorphins kind of negentropy packets or just conscious signals about the improved situation?

Second series of questions, observations, and ideas relates to the meridians, acu points, and "chi".

1. A permanent potential difference of same sign between head and tail could mean an accumulation of positive and negative charges to the ends of the of the system if only electron currents are present. If both electron and proton currents with opposite directions are present, there is no accumulation of charge but there is an accumulation of protons and electrons. Probably there exists a pumping mechanism forcing the electrons (and possibly also protons) to move against the potential gradient from the tail back to the head. This however requires metabolic energy and the simplest source of this energy would be just the energy of electrons

otherwise used to generate ATP. If so, the leakage would not be an unavoidable dissipative effect but a way to avoid charge accumulation.

If the pumping mechanism is not at work, this situation cannot continue for ever and the sign of the potential difference must eventually change and induce loss of consciousness. The simplest possibility is that the potential difference changes sign rhythmically. A natural question is whether the sleep-awake rhythm is unavoidable and corresponds to the oscillatory behavior of the head-to-tail voltage.

"Chi" would correspond electrons or their Cooper pairs in this picture. Abnormal chi flow (reduced flow, flow in wrong direction, accumulation of chi) would cause various problems including also insomnia in which too much electron charge tends to accumulate.

3. What is the nature of acupuncture meridians, what kind of currents flow along them, and why are they not directly observed? The most natural identification in TGD Universe would be in terms of magnetic flux tubes accompanied by parallel massless extremals (MEs) making possible also the propagation of dark photons used for control purposes and perhaps even in metabolism as already discussed. Dark currents along pairs of MEs and magnetic flux tubes are ideal for the transfoer of particles and energy.

   If the length of the superconducting "wire" is long in the scale defined by the appropriate quantum scale proportional to $\hbar$, the classical picture makes sense and charge carriers can be said to accelerate and gain energy ZeV. For large values of $\hbar_{eff}$ an oscillating Josephson current would be in question. Since Becker currents are associated with CNS, it would be natural to associate the meridians with neural pathways although this assignment is not necessary. Magnetic flux tube system defined kind of magnetic circulation which could serve as a template for the neural pathways. The transfer of energy with minimal dissipation would explain why a semiconductor like property is needed and why acupuncture points have a high conductivity value.

4. What about acu-points? Acu points are known to be in negative potential normally. This suggests that the density of electrons or their Cooper pairs at them is higher than elsewhere in the meridian. Could they server as kind of electron stores providing electrons to their environment to compensate for losses caused by ROS. This would make possible higher metabolic activity in presence of nutrient molecules since the rate for the electron transform cycle should be proportional to the density of energizable electrons, "chi".

   When the potential of the acu-point is reduced or become positive, under-nutrition follows. This should relate to various symptoms like pain at acupuncture points. Acupuncture needle as an electronic conductor would develop a charge distribution with a concentration of electrons to the acu-point, and would re-establish the metabolic activity. Pain would be signature of lack of negentropic entanglement (see **Fig.** http://tgdtheory.fi/appfigures/cat.jpg or **Fig. ??** in the appendix of this book) and positive/negative coloring of emotions and sensations would quite generally correlate with the amount of negentropic entanglement.

5. Nanna Goldman *et al* have provided empirical evidence (see http://tinyurl.com/4to42pc) [I56] for the expectation that the healing effect of the acupuncture involves metabolism (see the popular article in Sciencedaily (see http://tinyurl.com/3734uub) [I33]).

   The group has found that adenosine is essential for the pain killing effects of acupuncture. For mice with a normal adenosine level acupuncture reduced dis-comfort by two-thirds. In special "adenosine receptor knock-out mice" acupuncture had no effect. When adenosine was turned on in the tissues, the discomfort was reduced even in the absence of acupuncture. During and after an acupuncture treatment, the level of adenosin in tissues near the needles was 24 times higher than before the treatment. In the abstract of the article it is stated that it is known for long time that acupuncture generates signals which induce brain to generate natural pain killing endorphins but that also adenosine acts as a natural pain killer.

   Adenosine is the basic building block of AXP, X=M, D, T (adenosin-X-phosphate, X=mono, di, tri). Therefore the findings suggest that the flow of electrons from the needle to acu point loads metabolic batteries by providing electrons to electron transport cycle needed to generate ATP. Adenosine could be partially generated as decay products of AXPs. Tissue itself could

increase adenosine concentration to make possible its transformation to AXP utilizing electric field energy. From the popular article one cannot conclude whether the authors propose a connection with metabolism. The results are consistent with the assumption that the AXPs generated from adenosin accompany negentropic entanglement. This can occur in the scale of entire body and meridians could also make possible direct signalling with brain.

How can understand the semiconducting character of Becker's DC currents?

1. Becker assigns to the system involved with DC currents an effective semiconductor property. Could the effective semiconductor property be due the fact that the transfer of charge carriers to a smaller space-time sheet by first accelerating them in electric field is analogous to the transfer of electrons between conduction bands in semiconductor junction? If so, semiconductor property would be a direct signature of the realization of the metabolic energy quanta as zero point kinetic energies. For metabolic energy quantum of order .5 eV this however makes sense only if the electrons transferred to the smaller space-time sheet have energy slightly below the minimum energy for the transfer to the smaller space-time sheet in absence of the Becker potential. The situation would be critical and 1 mV voltage could serve as a kind of control knob.

   One can imagine the analog of this mechanism also when the external energy feed corresponds to a phase transition reducing p-adic length scale and increasing Planck constant so that the size of the space-time sheet remains unaffected. Again 1 mV voltage would have the role of control knob.

2. Supra currents flowing along magnetic flux tubes would make possible dissipation-free loading of metabolic energy batteries. This even when oscillating Josephson currents are in question since the transformation to ohmic currents in semiconductor junction makes possible energy transfer only during second half of oscillation period. Could this be a universal mechanism applying to various stages of the regeneration process? In quantal situation the metabolic energy quanta have very precise values as indeed required.

3. The findings of Becker provide support for electronic DC currents. The Cooper pairs of electrons are indeed the best candidates for the carriers of supra current by their small mass. In the minimal situation the currents defined by leaked electrons moving against potential gradient (utilising the energy used otherwise to generate ATP) could compensate the Becker currents and give rise to closed current loops without charge accumulation. If the electronic DC currents observed by Becker are much stronger than needed to compensate for the local electron leakage, a larger metabolically driven return current is needed to guarantee local charge neutrality. These currents seem to be assignable to CNS: maybe the two electron currents could be associated with sensory and motor pathways. An interesting question whether sympathetic-parasympathetic dichotomy also relates to electron currents in opposite directions.

4. Could also dark protonic and even ionic DC currents be present and running along their own flux tubes and perhaps defining cyclotron Bose-Einstein condensates? How large the scale of flux tubes can be: could it be much larger than that of biological body (by simple argument magnetic body should have layers with even size scale of Earth). What is the possible connection with cell respiration? When single ATP is generated, three protons are are pumped through the mitochondrial membrane utilising the energy liberated in electron transport cycle. This does not however require protonic currents in longer scales.

5. In regeneration process NEJs are formed. They could consist of pairs of MEs and magnetic flux tube mediating the electronic DC current during blastema generation and regeneration proper during which also control signals from CNS would be present. Since NEJs seems to resemble cell membranes in some respects, the ideas inspired by the model of cell membrane and DNA as TQC can be used. The model for nerve pulse and the model for DNA as topological quantum computer suggest that dark ionic currents flowing along magnetic flux tubes characterised by a large value of the effective Planck constant are involved with both meridians and NEJs. Magnetic flux tubes can act as DC current wires or Josephson junctions

generating oscillatory supra currents of ions and electrons. Also for large values of the effective Planck constant meridians look short in the relevant dark length scale and could act as Josephson junctions carrying oscillatory Josephson currents.

One can raise also questions about the relationship between DC currents and de-differentiation.

1. Could cell de-differentiation be caused by the presence of Becker's DC current? Also acupuncture is known to induce de-differentiation. Could the mere ability to charge metabolic energy batteries provided by electron feed induce de-differentiation, which manifests as an increased genetic expression? Can one see differentiation as an eliminative process forced by the reduction of the electron feed and inducing a selective reduction of gene expression? If this were the case, de-differentiation could be induced by a feed of surplus electrons to the system using either external electron current or additional electric field. Local electron density would correlate negatively with the degree of differentiation.

2. In this framework it might be possible to understand the claimed effects of external electric fields on the development of plants and fishes. In this case rejuvenation means return to the earlier evolutionary stages. Maybe ontogeny-recapitulates-phylogeny principle might allow to understand this if genome in some sense contains archive about earlier stages of evolution. This archive might be virtual and realised by an epigenetic mechanism selecting different patterns of gene expression using the same genome.

   If this is the case, the density of electrons or their Cooper pairs - "chi" - possessed by the cell would serve as a measure for the biological age of the cell and the meridian system feeding "chi" would serve as a rejuvenating agent with respect to gene expression. The average density of dark electrons would serve as a measure for the age of cell: the larger the density the higher the metabolic activity and the lower the biological age.

2.5.2   Quantum Model For Effective Semiconductor Property

Becker [J24] summarizes his findings by stating that living matter is an effective semiconductor. There are pairs of structures in positive and negative potential in various scales and the current between the plates of this effective capacitor flows when above some minimum potential difference. The current flows from positive to negative pole and could be an electron current. Also proton current in the opposite direction can be considered but the electron current is experimentally favored. For instance consciousness is lost when a magnetic field is used to deflect the current.

In TGD framework natural carriers of these currents would be magnetic flux tubes also carrying electric fields. A very simple deformation of the embedding of a constant longitudinal magnetic field also gives longitudinal electric field. With a slight generalization one obtains helical electric and magnetic fields. A crucial difference is that these currents would be quantal rather than ohmic currents even in the length scale of the biological body and even longer scales assignable to the magnetic body.

The following argument allows us to understand the physical situation.

1. A precise everyday analogy is vertical motion in the gravitational field of the Earth between surface and some target at given height h. If the kinetic energy is high enough, the particle reaches the target. If not, the particle falls back. In the quantum case one expects that the latter situation corresponds to a very small probability amplitude at the target (tunnelling to classically forbidden kinematic region).

2. Now the electric field replaces the gravitational field. Suppose that the classical electric force experienced by the particle is towards the capacitor plate taking the role of the surface of Earth. Below critical field strength the charged particle cannot reach the target classically and quantum mechanically this occurs only by tunnelling with vanishingly small probability.

3. Particles with opposite value of charge experience a force which accelerates them and classically they certainly reach the second plate. What happens in a quantum situation? It seems that this situation is essentially identical with the first one: one has linear potential in finite interval and wave functions are localized in this range. One can equivalently regard these states as localized near the second capacitor plate.

4. A good analogy is provided by atoms: classically the electron would end down at the nucleus but quantization prevents this. One can imagine also now stationary solutions for which the electric currents for individual charges vanish at the plates although classically there would be a current in another direction. Also quantum mechanically non-vanishing conserved current is possible: all depends on boundary conditions.

Basic model

Consider now the situation at more quantitative level.

1. One can assign complex order parameters Ψ_k to various Bose-Einstein condensates of supra phases and obey Schrödinger equation

$$i\partial_t \Psi_k = (-\frac{\hbar^2}{2m_k}\partial_z^2 + q_k E z)\Psi_k \ . \tag{2.5.1}$$

Here it is assumed that the situation is effectively one-dimensional. E is the value of constant electric field.

2. The Schrödinger equation becomes non-linear, when one expresses the electric field in terms of the total surface charge density associated with the plates of effective capacitor. In absence of external electric field it is natural to assume that the net surface charge densities σ at the plates are of opposite sign so that the electric field inside the capacitor is proportional to

$$\sigma = E = \sum \sigma_i = \sum_i q_i \overline{\Psi}_i \Psi_i \ . \tag{2.5.2}$$

This gives rise to a non-linear term completely analogous to that in non-linear Schrödinger equation. A more general situation corresponds to a situation in which the region interval $[a, b]$ bounded by capacitor plates a and b belongs to a flux longer tube like structure $[A, B]$: $[a, b] \subset [A, B]$. In this case one has

$$E_{tot} = E + E_0 \ . \tag{2.5.3}$$

This option is needed to explain the observations of Becker that the local strengthening of electric field increases the electron current: this would be the case in the model to be discussed if this field has a direct opposite to the background field E_0. One could also interpret E as quantized part of the electric field and E_0 as classical contribution.

3. The electric currents are given by

$$j_k = \frac{i\hbar q_k}{2m_k}\overline{\Psi}_k \partial_z^{\leftrightarrow} \Psi_k \ . \tag{2.5.4}$$

In stationary situation the net current must vanish:

$$\sum_k j_k = 0 \ . \tag{2.5.5}$$

A stronger condition is that individual currents vanish at the plates:

$$j_k = 0 \ . \tag{2.5.6}$$

It must be emphasized that this condition does not make sense classically.

Explicit form of Schrödinger equation

Consider now the explicit form of Schrödinger equation in a given electric field.

1. The equation is easy to solve by writing the solution ansatz in polar form (the index k labelling the charge particle species will be dropped for notational convenience).

$$\Psi \quad = \quad R(aexp(iU) + bexp(-iU))exp(-iE_n t) \tag{2.5.7}$$

For real solutions current vanishes identically and this is something which is not possible classically. It is convenient to restrict the consideration to stationary solutions, which are energy eigen states with energy value E_n and express the general solution in terms of these.

2. The Schrödinger equation reduces with the change of variable

$$z \quad \rightarrow \quad \frac{(z - z_0)}{z_1} \equiv x \ ,$$

$$z_0 \quad = \quad \frac{E_n}{qE} \ , \quad z_1 = \left(\frac{\hbar^2}{2mqE}\right)^{1/3} \ . \tag{2.5.8}$$

to

$$(\partial_x^2 + x)\Psi \quad = \quad 0 \ . \tag{2.5.9}$$

The range $[0, z_0]$ for z is mapped to the range $[-z_0/z_1, 0]$. z_0/z_1 has positive sign as is easy to verify. The value range of x is therefore negative irrespective of the sign of qE. This is the differential equation for Airy functions (see `http://tinyurl.com/6b8yh7`) [B1]. Airy functions are encountered in WKB approximation obtained by linearing the potential function: $V(x) = ax + b + O(x^2)$.

The change of variable leads automatically to solutions restricted near the plate where the situation is completely analogous to that in the gravitational field of the Earth. For stationary solutions a test charge in a given background field would be localized near the capacitor plate with opposite sign of charge. A strong background field could be created by charges which do not correspond to the ionic charges defining ionic currents. Electrons and protons could define this field possibly associated with flux tubes considerably longer than the distance between capacitor plates.

3. Using the polar representation $\Psi = Rexp(iU)$ Schrödinger equation reduces to two equations

$$\begin{aligned} \left[(\partial_x^2 - U_x^2 + x)R\right]cos(U) \quad &+ \quad [U_{xx} + 2\partial_x R\partial_x U]sin(U) = 0 \ , \\ \left[(\partial_x^2 - U_x^2 + x)R\right]sin(U) \quad &- \quad [U_{xx} - 2\partial_x R\partial_x U]cos(U) = 0 \ . \end{aligned} \tag{2.5.10}$$

Note that both (R, U) and $(R, -U)$ represent solutions for given value of energy so that the solution can be chosen to be proportional to $cos(U)$ or $sin(U)$. The electric current j is conserved and equal to the current at $x = 0$ and given by

$$j \quad = \quad \frac{\hbar}{2m}\frac{U_x}{z_1}R^2 \ , \quad z_1 = \left(\frac{\hbar}{2mqE}\right)^{1/3} \ . \tag{2.5.11}$$

The current vanishes if either U_z is zero or if the solution is of form $\Psi = Rsin(U)$.

Semiclassical treatment

In semiclassical approximation the potential is regarded as varying so slowly that it can be regarded as a constant. In this situation one can write the solution of form $Rexp(iU)$ as

$$\Psi = R_0 exp\left(\frac{i}{\hbar}\int_0^z \sqrt{2m}\sqrt{E-qEz}dz\right) = R_0 exp\left(i\int_0^x x^{1/2}dx\right) \quad . \tag{2.5.12}$$

The plate at which the initial values are given can be chosen so that the electric force is analogous to gravitation at the surface of Earth. This requires only to replace the coordinate z with a new one, vanishing at the plate in question - and gives to the energies a positive shift $E_0 = qE_0h$.

1. The semiclassical treatment of the equation leads to Bohr rules

$$\frac{\oint p_z dz}{\hbar} = \frac{2}{\hbar}\int_0^h p_z dz = n \quad . \tag{2.5.13}$$

   This gives

$$\frac{\oint p_z dz}{\hbar} = \frac{2\sqrt{2m}}{\hbar}\int_0^h \sqrt{E_n - qEz}dz = 2\int_0^{x_0} x^{1/2} = \frac{4}{3}x_0^{3/2} = n \quad . \tag{2.5.14}$$

   Note that the turning point for classical orbit corresponds to $z_{max} = E_n/qE$.

2. One obtains

$$E_n = \frac{1}{2}\left(\frac{nqE\hbar^2}{r\sqrt{m}}\right)^{2/3} \quad , \quad r = \int_0^1 (1-u)^{1/2}du = \frac{2}{3} \quad . \tag{2.5.15}$$

   The value of z_{max} is

$$z_{max} = \frac{E_n}{qE} = \frac{n^{2/3}}{2r^{2/3}}\left(\frac{\hbar^2}{qEm}\right)^{1/3} \quad . \tag{2.5.16}$$

3. The approximation $R = R_0 = constant$ can make sense only if the position of the second plate is below z_{max}. This is possible if the value of n is large enough ($n^{2/3}$ proportionality), if the mass m of the charged particle is small enough ($m^{-1/3}$ proportionality) raising the electron and also the proton to a special position, or if the strength of the electric field is small enough ($E^{-1/3}$ proportionality). The value z_{max} is proportional to $\hbar^{2/3}$ so that a phase transition increasing Planck constant can induce current flow.

Possible quantum biological applications

The proposed model for quantum currents could provide quantum explanation for the effective semiconductor property of Becker's DC currents.

1. The original situation would be stationary with no currents flowing. The application of an external electric field in the correct direction would reduce the voltage below the critical value and currents would start to flow. This is consistent with Becker's findings if there is a background electric field E_0 with direction opposite to that of the applied field has a direction opposite to E_0 so that the field strength experienced by charged particles is reduced and it is easier for them to reach the second plate.

2. Becker's DC currents appear in several scales. They are assigned with the pairs formed by CNS and perineural tissue (this includes also glia cells) and by frontal and occipital lobes. Acupuncture could involve the generation of a DC supra current. The mechanism would be essential in the healing. Also the mechanism generating qualia could involve generation of supra currents and dielectric breakdown for them. The role of the magnetic flux tubes in TGD inspired biology suggests that the mechanism could be universal. If this were the case one might even speak about a Golden Road to the understanding of living matter at the basic level.

Even the generation of nerve pulse [K92] might be understood in terms of this mechanism. One can argue that neurons have a higher evolutionary level than the system pairs to which only electron currents or electron and proton currents can be assigned. This is because the value of the effective Planck constant is higher for the magnetic flux tubes carrying the quantal ionic currents.

1. For Bose-Einstein condensate the simplest choice is $n = 1$ at both plates. The energy eigenvalues would naturally differ by the shift $E_0 = qE_0h$ at the two plates for a given particle type. Under these assumptions the current can flow appreciably only if the voltage is below the minimum value. This is certainly a surprising conclusion but brings in mind what happens in the case of neuronal membrane. Indeed, hyper-polarization has a stabilizing - something difficult to understand classically but natural quantum mechanically.

2. The reduction of membrane potential slightly below the resting potential generates nerve pulse. Also a phase transition increasing the value of the effective Planck constant might give rise to quantal direct currents and generate flow of ionic currents giving rise to nerve pulse. Stationary solutions are located near either capacitor plate. What comes to mind is that the nerve pulse involves a temporary change of the capacitor plate with this property.

3. If the electron and proton currents flow as direct currents, one encounters a problem. Nerve pulse should begin with direct electronic currents and be followed by direct protonic currents and only later ions should enter the game if at all. The existing model for nerve pulse however assumes that at least electrons flow as oscillating Josephson currents rather than direct quantal currents. This is quite possible and makes sense if the cell membrane thickness is small - that is comparable to electron Compton length as assumed in large $\hbar$ model for the nerve pulse. This assumption might be necessary also for proton and would make sense if the Planck constant for protonic flux tubes is large enough. For ions the Compton length would be much smaller than the thickness of cell membrane and direct currents would be natural.

   If the value of the effective Planck constant is the same for biologically important ions, direct quantum currents would be generated in definite order since in $h < z_{max}$ one has $z_{max} \propto m^{-1/3} \propto A^{-1/3}$. The lightest ions would start to flow first.

   (a) Nerve pulses canbe generated by voltage gated channels for potassium and calcium. Voltage gated channels would correspond to magnetic flux tubes carrying electric field. For voltage gated channels Na^+ ions with atomic weight $A = 23$ and nuclear charge $Z = 11$ start to flow first, then K^+ ions with atomic weight $A = 39$ and $Z = 19$ follow. This conforms with the prediction that the lightest ions flow first. The nerve pulse duration is of the order of 1 millisecond at the most.

   (b) Nerve pulses can be also generated by voltage gated Ca^{+2} channels. In this case the duration can be 100 ms and even longer. Ca has $A = 40$ and $Z = 20$. The proper parameter is $x = r^2/qA$, $r = \hbar/\hbar_0$. One has

$$\frac{x(Ca^{++})}{x(Na^+)} = \left(\frac{r(Ca^{++})}{r(Na^+)}\right)^2 \times \frac{23}{2 \times 40} \quad . \tag{2.5.17}$$

   $r^2(Ca_{++}) \sim 2r^2(Na_+)$ would allow to compensate for the increased weight and charge of Ca_{++} ions.

4. The objection is that Na^+ and K^+ are not bosons and therefore cannot form Bose-Einstein condensates. The first possibility is that one has Cooper pairs of these ions. This would imply

$$\frac{x(Ca^{++})}{x(2Na^+)} = (\frac{r(Ca^{++})}{r(Na^+)})^2 \times \frac{23}{20} \ .$$

Ca^{++} and Na^+ pair would be in very similar position for a given value of Planck constant. This is a highly satisfactory prediction. Another manner to circumvent the problem is more science fictive and assumes that the Na^+ ions are exotic nuclei behaving chemically as Na^+ but having one charged color bond between nucleons [L3].

It remains to be seen whether this model is consistent with the model of cell membrane as almost vacuum extremal or whether the vacuum extremal based model could be modified by treating ionic currents as direct currents. In the vacuum extremal model classical Z^0 gauge potential is present and would give a contribution to the counterpart of Schrödinger equation. The ratio $x(Ca^{++})/x(2Na^+)$ for the parameter $x = r^2/q(A - Z)A$ (em charge q is replaced with neutron number in good approximation) equals to 1.38 and is not therefore very far from unity.

The many-sheetedness of space-time is expected to play a key role and one should precisely specify which sheets are almost vacuum extremals and which sheets are far from vacuum extremals. One expects that magnetic flux tubes are far from vacuum extremals and if voltage gated ionic channels are magnetic flux tubes, the proposed model might be consistent with the model of cell membrane as almost vacuum extremal.

The effects of ELF em fields on vertebrate brain

The effects of ELF em fields on vertebrate brain occur both in frequency and amplitude windows. Frequency windows can be understood if the effect occur at cyclotron frequencies and correspond to absorption of large $\hbar$ photons. A finite variation width for the strength of magnetic field gives rise to a frequency window. The observed quantal character of these effects occurring at harmonics of fundamental frequencies leads to the idea about cyclotron Bose-Einstein condensates as macroscopic quantum phases. The above considerations support the assumption that fermionic ions form Cooper pairs.

I have tried to understand also the amplitude windows but with no convincing results. The above model for the quantum currents however suggests a new approach to the problem. Since ELF em fields are in question they can be practically constant in the time scale of the dynamics involved. Suppose that the massless extremal representing ELF em field is orthogonal to the flux tube so that the ions flowing along flux tube experience an electric force parallel to flux tube. What would happen that the ions at the flux tube would topologically condensed at both the flux tube and massless extremal simultaneously and experience the sum of two forces.

This situation is very much analogous to that defined by magnetic flux tube with longitudinal electric field and also now quantum currents could set on. Suppose that semiconductor property means that ions must gain large enough energy in the electric field so that they can leak to a smaller space-time sheet and gain one metabolic quantum characterized by the p-adic length scale in question. If the electric field is above the critical value, the quantum current does not however reach the second capacitor plate as already found: classically this is of course very weird. If the electric field is too weak, the energy gain is too small to allow the transfer of ions to smaller space-time sheet and no effect takes place. Hence one would have an amplitude window.

The amplitude window occur in widely separate ranges 1-10 V/m and around 10^{-7} V/m. Of course, also other ranges might be possible. Fractality and the notion of magnetic body suggests a possible explanation for the widely different frequency ranges. Both p-adic length scale hypothesis and the hierarchy of Planck constants suggest that some basic structures associated with the cell membrane have fractal counterparts in a wide length scale range and correspond to binary structures. Magnetic flux tubes carrying quantal DC currents of Becker would be the most natural candidate in this respect since these currents appear in several length scales inside organism. Also the counterparts of lipid layers of cell membrane could be involved. If so, one must include to the hierarchy of amplitude windows also fields in the range corresponding to the cell membrane resting

potential of about 6×10^6 V/m. This is of course only a rough order of magnitude estimate since perturbations of these field are in order.

Fractality motivates some guess for voltage and electric field.

1. The voltage along the flux tube could be invariant under the scaling of Planck constant. The interpretation could be that the charges at the ends of the linear structure generate an electric flux running along the structure do not depend on the length L of the structure so that the electric field along linear structure behaves as $1/L \propto 1/h_{eff}$ as a function of the length scale $L \propto h_{eff}$ so that voltage between the ends does not depend on the length of the structure. This would give rise to a universal amplitude window for voltage rather than potential. The cell membrane electric field of 6×10^6 V/m would correspond to the field 6 mV/m. This kind of voltages could be associated with Becker's DC currents and the order of magnitude would be around few mV.

   Note that if the electric flux is like that between point charges, the scaling law $E \propto 1/h_{eff}^2$ holds true.

2. There could be also a constant electric field along microtubular structures due to polarization - most naturally tubulin polarization. This field strength serves as a candidate for a universal amplitude window for electric field.

   The idea that the direct currents of Becker run between lipid layers of cell does not conform with the hypothesis about generalized Josephson currents between them. There are electric fields along microtubules and one could wonder whether the DC voltages of Becker could relate to the voltages between the ends of linear structures formed by axonal and dendritic microtubules connected to each other by MAPs - single MT can have a length up to about 1 cm. The longitudinal electric field due to the dipole moments of tubulins and confined to tubulin structure does not depend on its length L, and the electric field of 1 mV/m would correspond 10^3 V/μm, which is by order of magnitude larger than the constant longitudinal dipole electric field of order 10^2 eV/μm generated by tubulin dipoles estimated to have strength 337 Debye in [I76] (note that MT has radius of $R = 25$ nm, thickness of $\Delta R = 4$ nm and length of $d = 8$ nm and the volume of MT fragment defined by 13 parallel tubulins is given by $V = 13 \times 2\pi R^2 \Delta R$ and that electric is $E = p/V$). If Becker's direct currents correspond to electric fields due to the charge difference between the ends of tubulins, one can consider the possibility that Becker's longitudinal electric fields have micro.tubular origin.

3. Electric field in the range $E = 1 - 10$ V/m assignable to EEG would correspond to field of $(1 - 10) \times 10^3$ V/μm and seems to be too large to be assigned with microscopic structures. DNA is a possible candidate since the smaller thickness of DNA would increase the dipole moment density by a factor of order 10^3 from that for MTs. The electric field of 10^{-7} eV/m seems to be associated with much larger structure than organism.

Effects of 50 Hz magnetic fields on living matter

The vision about the role of cyclotron Bose-Einstein condensates was inspired by the effects of ELF em fields on vertebrate brain. The magnetic field strength explaining the effects was about.2 Tesla, 2/5 of the nominal value for the strength of Earth's magnetic field.

There are also other experiments have demonstrated that oscillating electromagnetic fields have effects on living matter. In particle oscillatory magnetic fields with frequency of 50 Hz and with field strengths typically in the range.1-1 mT are used: these effects are summartized in [J117]. Even fields of order.14 Tesla are used.

It is interesting to look at the values of basic parameters associated with these fields.

1. For 50 Hz oscillation frequency the wave length λ is 6000 km to be compared with the radius of Earth which is 6371 km. If one takes seriously the notion of magnetic body this need not be an accident. I do not know how essential it is to have just 50 Hz frequency. The magnetic field is nearby oscillating dipole field (see `http://tinyurl.com/36c4pfg`) up to distances of order λ and radiation field at much longer distances. Therefore the field in question is in good approximation nearby field as fart as biological body is considered. For magnetic body the radiation field could dominate

2. For the endogenous magnetic field $B_{end} = .2$ Gauss cyclotron frequencies of ions are in EEG range: Ca^{++} cyclotron frequency is 15 Hz. The scaling up to r=.1-1 mT means scaling of cyclotron frequencies by a factor $5 - 50$. For Ca^{++} this would give frequency range 75-750 Hz. For K^+ and Cl^+ ions the frequency range would be about 35-375 Hz.

3. The magnetic length $r = \sqrt{2/eB}$ characterizing flux tube thickness for flux quantization with minimum value of flux is for $B = .05$ mTesla equal to 5 μm. For the fields in the range .1-1 mTesla it is in the range 3.5 μm- 1.1 μm. 2.5 μm corresponds to p-adic length scales $L_e(k)$ associated with Gaussian Mersenne $M_{G,k} = (1+i)^k - 1$, $k = 167$, and Gaussian Mersenne correspondng to $k = 163$ would correspond to p-adic length scale .36 μm. .14 Tesla corresponds to magnetic length of 9.4 nm rather near to cell membrane thickness of 10 nm which corresponds to p-adic length cale $L_e(151)$ assignable to Gaussian Mersenne $M_{G,151}$.

The effects of polarized light on living matter

Polarized light is known to have effects on living matter [J117]. For instance, Peter Gariaev has found that the polarized light generated by living matter sample irradiated by polarized laser light has effects on distant organism and there are even indications that genetic code might be realized in terms of radiation patterns [K127]. The quantum model for Becker currents suggest that these effects result as a modification of the voltage between the ends of magnetic flux tubes If the flux tubes are near criticality for the generation of quantal DC currents, polarized light could be utilized both communication and control purposes wheres the acceleration in the electric fields along flux tubes would serve as a provider of metabolic energy allowing to load metabolic batteries. This process could be initiated by an electromagnetic signal inducing generation of quantal currents. The same basic mechanism could be at work also in DNA transcription, replication and other similar processes.

If the polarized low frequency radiation corresponds to a massless extremal (ME) orthogonal to the flux tube such that the polarization of the radiation is parallel to the flux tube, the voltage is affected by a contribution given by $\Delta V = Ed$, d the thickness of ME. If the flux tube is near criticality to a generation of quantal currents this change of voltage could serve as a signal inducing the generation of quantal currents.

The maximal effect is obtained for the flux tubes having direction parallel to the electric polarization so that the effect is highly selective. In the case of DNA double strand the direction of flux tube changes so that the effect would be maximal on DNAs which correspond to the same angular position on the super-coil of radius of order 10 nm formed by DNA double helix. This allows to imagine signals for which temporal variation of polarization direction means scanning of DNA.

It is known that the energy of radiation can be transformed to metabolic energy. For instance, IR light for which photons have energies of order metabolic quantum has biological effects [I143]. The mechanism could be following. Suppose that the electric field of IR photon is parallel to the flux tube which carries an electric field and is near criticality for the generation of quantal DC currents. If the direction of polarization is correct, the additional contribution to electric field induces direct current and acceleration of electrons and protons and their transfer to smaller space-time sheets and therefore loading of metabolic batteries. This could also make generation of ATP possible.

Suppose that one takes seriously the model for remote replication of DNA [K127] involving flux tubes connecting identical DNA nucleotides and that the radiation propagating along them induces quantal currents along the receiving DNA inducing replication and perhaps even transcription. The direction of polarization for the emitted radiation should be parallel to the DNA strand locally and during its travel to the target the polarization should remain orthogonal to the flux tube so that one would have what might be called polarization window. Parallel translation of the polarization vector in the induced metric suggests itself.

Support for the proposed interaction mechanism of em radiation fields with flux tubes

The basic prediction of the interaction mechanism is that the effects of em field with a given frequency occur only at the second half period when the direction of electric field is "correct". This prediction might be testable. In fact, there is evidence for this interaction mechanism in the

case of theta waves of EEG. The memory storage occurs only at the second half of the theta wave This is discussed from different point of view in [K5].

The place coding by phase shifts was discovered by O′Reefe and Recce [J106]. In [J126, J125]. Y. Yamaguchi describes the vision in which memory formation by so called theta phase coding is essential for the emergence of intelligence. It is known that hippocampal pyramidal cells have "place property" being activated at specific "place field" position defined by an environment consisting of recognizable objects serving as landmarks. The temporal change of the percept is accompanied by a sequence of place unit activities. The theta cells exhibit change in firing phase distributions relative to the theta rhythm and the relative phase with respect to theta phase gradually increases as the rat traverses the place field. In a cell population the temporal sequence is transformed into a phase shift sequence of firing spikes of individual cells within each theta cycle.

Thus a temporal sequence of percepts is transformed into a phase shift sequence of individual spikes of neurons within each theta cycle along linear array of neurons effectively representing time axis. Essentially a time compressed representation of the original events is created bringing in mind temporal hologram. Each event (object or activity in perceptive field) is represented by a firing of one particular neuron at time τ_n measured from the beginning of the theta cycle. τ_n is obtained by scaling down the real time value t_n of the event. Note that there is some upper bound for the total duration of memory if scaling factor is constant.

One can say that neurons in ensemble provide a representation for the external world and the location of the rodent in the external world is represented as a firing of a neuron in this landscape. Besides this also temporal scaling down by a factor about ten is carried out so that actual event is represented as much shorter copies of it. Obviously this represents temporal fractality.

This scaling down - story telling - seems to be a fundamental aspect of memory. Our memories can even abstract the entire life history to a handful of important events represented as a story lasting only few seconds. This scaling down is thought to be important not only for the representation of the contextual information but also for the memory storage in the hippocampus. Hierarchy of Planck constants and phase transitions changing Planck constant make this story building possible.

The finding of Yamaguchi and collaborators relevant in the recent context is that the gradual phase shift occurs at half theta cycle whereas firings at the other half cycle show no correlation [J126]. The proposed model for the interaction of theta waves with flux tubes could explain this naturally. The relevant neural sub-system would be critical to the generation of quantal DC current only when the direction electric field of synchronizing theta wave generated by magnetic body is correct. Hence synchronous neural activity would be induced only at second half cycle of theta wave and firing would be random during the other half cycle.

2.5.3 A Model For Remote Gene Expression Based On Becker Currents

If one accepts the notion of magnetic body as intentional agent, the basic challenge is to understand how magnetic body realizes its intents as remote mental interactions on biological body. This model must of course apply also to the more conventional remote mental interactions such as remote realization of intent.

The hypothesis is that electromagnetic and possibly also other massless classical fields assignable to so called massless extremals are in a key role. Also cyclotron frequencies characterizing magnetic bodies play a key role. The vision is that magnetic flux sheets traverse many-sheeted DNA in various scales giving rise to a hierarchy of genomes and coherent gene expression in scales of cell, organelles, organism, and even population, and species. Hierarchy of Planck constants is in an essential role in realizing this hierarchy in terms of photons with energies above the thermal energy at physiological temperature and having spectrum of wavelengths coming as multiples $\lambda = n\lambda_0$, $n = \hbar/\hbar_0$.

The findings of Benveniste and followers relating to water memory and homeopathy, the recent work of group led by HIV Nobelist Luc Montagnier coupling the findings with genetics and suggesting a new nanoscale realization of genetic code [L6]), the work of the group of Popp with bio-photons identified as decay produces of large $\hbar$ photons with visible energies (in particular dark EEG photons), and the work of Peter Gariaev and collaborators supporting remote gene expression and replication discussed [K127] suggest that electromagnetic radiation is indeed involved. In the case of water memory and homeopathy the spectrum of cyclotron frequencies for the chemical

invader characterizes it and induces immune response trying to eliminate it. I have also proposed a model for how genes coding for proteins eliminating the invader could be generated almost automatically: the model is based on the predicted realization of vertebrate genetic code in terms of dark proton states [K53]. DNA would like an animal which sniffs the invaders magnetic body and automatically reacts to the smell.

The discussions with Lian Sidorov and people who have realized that new era is beginning in biology have served as a driving force in the attempts to formulate in more detail TGD inspired view about how remote mental interactions - which are basic element of the model in TGD framework - might be realized. As a matter fact, I have added to my homepage a new book summarizing briefly the recent view about quantum TGD and its applications to quantum consciousness, quantum biology, to quantum neuroscience, and to remote mental interactions with some proposals for possible tests [K112]).

To start with, suppose that in the case of biological target realization of intent in the simplest situation reduces to expression of genes. This is of course a strong limitation to the type of remote mental interactions. The challenge is to develop a model for remote realization of genetic activities like replication, and transcription. For some time ago I proposed a model with Peter Gariaev [K127] but it was still too clumsy since it required too much of information transfer between the genomes of sender and receiver. Much simpler model involving only sending of simple commands initiating genetic programs suggests itself. The following proposal tries to achieve this and involves three basic ideas.

1. The idea of password and addressing is familiar from ordinary computers. Collection of frequencies as password/address allows to reach tuned targets without specific targeting of the command. This is a dramatic improvement to the previous model.

2. Password and fractal addressing realized in terms of frequencies coupling resonantly (already in the original model: I did not however realize the implications of resonant coupling!) and the hierarchy of Planck constants to realize the hierarchical addressing. I have discussed analogous addressing based on information molecules and their receptors at the biochemical level to realize magnetic flux tube connections between sender and target inside organism (hormonal action would be very analogous to what I am proposing here).

3. Becker's DC currents as supra currents flowing along DNA and activated optimally when the incoming laser light has polarization parallel to DNA's local direction, activation of super currents would mean activation of the gene. This is second new element to the original model.

In the following I discuss this with more details.

The analogy with ordinary computer

Consider first the analog of remote mental interactions for ordinary computer. Computer sends a password to the other computer and after that it can use it to run programs of the other computer. Whisling to a dog is another example: extremely simple command activates arbitrary complex programs.

In the recent case electromagnetic radiation with a given frequency coupling resonantly like radio signal to a tuned radio receiver would be the simplest command activating the target. There would no need to specify the direction or distance of the target precisely since essentially mass communications would be in question: intent would be enough. Password could consist of several frequencies which must be received simultaneously by the target before it would activate and tunes to receive more frequencies representing simple commands - perhaps acting on the intronic portion of DNA and activating the genome to remote gene expression or something else such as activating DNAs of other cells by sending similar em addresses!

I have discussed topological quantum computer programs (see `http://tinyurl.com/y84g3tk7`) based on braiding could look like in this framework [L11]. Also here addressing but now realized as information molecule-receptor pair would play a key role.

Hierarchy of Planck constants and hierarchical addressing

Fractal hierarchy of frequencies (in Peter's experiment laser light induced generation of radiation at frequencies down to about 10 kHz) would allow to transform passwording to addressing. Very naïvely, the longest wavelengths: about 10^4 meters would reach the tuned receivers in nearly the same phase in a region of this size. One would have some subregions in tune. The shorter wavelengths would allow to pinpoint the tuned receivers inside each of these subregions and so on. This would be fractal addressing with most significant bits correspond to the longest wavelengths. Only those receivers which would be tuned to all frequencies would start to express the gene in the case of AND logic. Of course, also other Boolean functions of tuned-not tuned bits can be considered.

A good guess is that all photons correspond to the same energy of visible photon and only Planck constant varies. For ordinary value of Planck constant one would have a photon with wavelength of order size scale of single cell, and the frequencies in this range would select single gene in the genome ofa particular kind of cell, say neuron within particular region of brain.

In Peter Gariaev's experiment involving 2 eV incoming red laser light the outgoing photons would have same energy but larger Planck constant so that also wavelengths would be longer and range down to at least 3×10^4 meters corresponding to radiofrequency scale of 10 kHz. What is interesting that 2 eV is 4 times the nominal value of the metabolic energy quantum of.5 eV identifiable as zero point kinetic energy of electron or proton for the p-adic length scale $L_e(151)$ corresponding to cell membrane thickness and Gaussian Mersenne $M_{151} = (1 + i)^{151} - 1$. Could it be that 2 eV could be preferred photon energy or is its use simply due to the unavailability of continuous frequency spectrum for laser light. And why the laser light induces the generation of the command inducing remote gene expression?

This picture conforms with Peter's experiment and with the reports of Benveniste and followers about the possibility of representing homeopathic remedy using very low frequency spectrum - presumably cyclotron frequencies - assignable to remedy. These frequencies would be addresses for genes activating genes transcribing building bricks of biomolecules of immune response eliminating the substance from the organism. The proposal could be seen as a generalization of Benveniste's observation and realization of wave DNA proposal.

DNA supra currents and activation of genes by Becker mechanism

The third bulding brick of the model would be quantum model for Becker currents (see `http://tinyurl.com/ybnjk9bq`) [L12] as supra currents or quantal DC currents: also this element is new. Assume - in accordance with the general vision - that these supra currents can flow also along the strands of many-sheeted DNA (flux sheets associated with the strand, entire hierarchy labelled by the values of $\hbar$). Assume also that the interaction of polarized photons addressing for genes with DNA is such that the electric fields of DNA flux tube and "massless extremal" representing laser beam superpose and charges (electrons) experience the superposition of field already present and the field of ME. If the net electric field is near criticality originally (think as analog neuronal membrane) and becomes over-critical, quantal Becker current starts to flow and the machinery responsible for gene activation is activated.

This means also the activation of metabolic machinery since the acceleration of electrons in the electric field gives them energy making possible a transfer to smaller space-time sheets where they form Cooper pair like states with negentropic entanglement. Metabolic energy corresponds to zero point kinetic energy and negentropic entanglement is relevant from the point of view of consciousness: in the case of healing understood as a regeneration of negentropic resources this aspect is especially important. This mechanism generates high energy phosphate bonds in ATP and the decay ATP $\rightarrow$ ADP liberates the metabolic energy and destroys the negentropic entanglement possibly associated with ATP so that the second law in generalized form (see `http://tinyurl.com/yakmqhz6`) [L8] allowing local generation of genuine negentropy (but assigned to information carried by entanglement defining a quantum rule) wins after all.

It could also happen that the decay of ATP generates dark photon or photons absorbed by cyclotron condensate at magnetic flux tube. The excited state is non-local single particle excitation and involves very simple negentropic entanglement between the particles of the condensate. In this case the negentropy of ATP would be transformed to the negentropy of the magnetic flux tube

or even several of them if large value of Planck constant is associated with the photon. This mechanism could allow the generation of negentropic entanglement associated with attention. The storage of metabolic energy in photosynthesis could involve similar excitation of cyclotron state at the first step. The most plausible candidate is cyclotron condensate for electron Cooper pairs. Also electrons filling state up to some Fermi energy could be in question. In this case the excitations would be excitation in longitudinal degrees of freedom of the flux tube generating current.

2.5.4   DNA, Speech, Music, And Ordinary Sound

Peter Gariaev's group has made rather dramatic claims about DNA during years [I53, I54, I95, I94].

1. The group has proposed that the statistical distributions of nucleotides and codons in the intronic portion of DNA resemble the distribution of letters and words in the natural languages [I94]. For instance, it is proposed that Zipf law [J76] applying to natural languages applies to the distributions of codonds in the intronic portion of DNA. One can study the popularity of the words in natural languages and order them against their popularity. Zipf law states that the integer characterizing popularity is in constant proportion to the number of times it appears in given long enough text.

2. It has been also claimed that DNA can be reprogrammed using modulated laser light or even radio waves. I understand that reprogramming means a modified gene expression. Gariaev's group indeed proposes that the meaning of the third nucleotide (having a rather low significance in the DNA-amino-acid correspondence) in the genetic codon depends on the context giving rise to a context dependent translation to amino-acids. This is certainly a well-known fact for certain variants of the genetic code. This context dependence might make possible the re-programming. The notion of dark DNA allows to consider much more radical possibility based on the transcription of dark DNA to mRNA followed by translation to amino-acids. This could effectively replaced genes with new ones.

3. Also the modulation of the laser light by speech is claimed to have the re-programming effect. The broad band em wave spectrum resulting in the scattering of red laser light on DNA is reported to have rather dramatic biological effects. The long wave length part of this spectrum can be recorded and transformed to sound waves and these sound waves are claimed to have the same biological effects as the light. The proposal is that acoustic solitons propagating along DNA represent this effect on DNA.

I do not have the competence to make statements about the plausibility of these claims. TGD view about quantum biology makes also rather strong claims. The natural question is however whether a justification for the claims of Gariaev and collaborators could be found in TGD framework? In particular, can one say about possible effects of sound on DNA. One intriguing fact about sound perception is that music and speech have meaning whereas generic sounds to not. Could one say something interesting about how this meaning is generated at the level of DNA?

Basic picture

Before continuing it is good to restate the basic TGD inspired ideas about the generation of meaning.

1. The generation of the negentropic entanglement is the correlate for the experience of the meaning. In the model inspired by Becker's findings [L12], the generation of negentropic entanglement (see **Fig.** `http://tgdtheory.fi/appfigures/cat.jpg` or **Fig. ??** in the appendix of this book) involves a generation of supra currents along flux tubes moving in the electric field parallel to them. This is a critical phenomenon taking place when the voltage along the flux tube is near critical value. The generation of nerve pulse near critical value of the resting potential is one example of this criticality. Becker's direct currents involved with the healing of wounds is another example.

The flow of the supra current gives rise to the acceleration of charges along the flux tubes and generation of Cooper pairs or even many-electrons systems at smaller space-time sheets in

negentropically entangled state and carrying metabolic energy quantum as zero point kinetic energy. The period of negentropic entanglement gives rise to a conscious experience to which one can assign various attributes such as understanding, attention, and so on. Negentropic entanglement would measure the information contained by a rule having as instances the state pairs in the quantum superposition defining the entangled state. When the period of negentropic entanglement ceases, the metabolic energy is liberated.

2. Remote activation of DNA by analogs of laser beams is another essential piece of TGD inspired quantum biology [L12]. In the proposed addressing mechanism a collection of frequencies serves as a password activating intronic portions of DNA. This would take place via a resonance for the proposed interaction between photons and dark supra currents flowing along magnetic flux tubes and perhaps also along DNA strands or flux tubes parallel to them. The superposition of electric fields of photons (massless extremals) with the electric fields parallel to flux tubes (so that massless extremals serving as correlates for laser beams would traverse the flux tube in orthogonal direction).

3. The flux tubes, and more generally flux sheets labelled by the value of Planck constant, and along which the radiation arrives would be transversal to DNA and contain DNA strands. This kind of flux tubes and sheets also define the connections to the magnetic body, and form parts of it. A given flux sheet would naturally select the portion of DNA, which is activated by the radiation: it could be a portion of intronic part of DNA activating in turn a gene. These flux tubes and sheets could be connected to the lipids of nuclear and cell membranes - also cell membranes of other cells - as assumed in the model of DNA as topological quantum computer [K5]. The sheets could also give rise to a hierarchy of genomes - besides genome one would have super-genome in which genomes are organelles are integrated by flux sheets to a large coherently expressed structure containing individual genomes like page of a book contains lines of text. These pages would be in turn organized to a book - hyper-genome as I called it. One could have also libraries, etc... There would fractal flux quanta inside flux quanta structure.

Phonons and photons In TGD Universe

Consider next phonons and their coupling to photons in TGD Universe.

1. Sound waves could quite well transform to electromagnetic radiation since living matter is piezo-crystal transforming sound to radiation and vice versa. Microwave hearing represents an example of this kind transformation. This would require that photons of given energy and varying value of Planck constant couple to phonons with the same energy, Planck constant, and frequency.

2. Whether one can assign to phonons a non-standard value of Planck constant is not quite clear, but there seems to be no reason preventing this. If so, even photons of audible sounds would have energies above thermal threshold and have direct quantal effects on living matter if they have same Planck constant as the photons with same frequency.

3. Acoustic phonons represent longitudinal waves and this would require longitudinal photons. In Maxwell's electrodynamics they are not possible but in TGD framework photon is predicted to have a small mass and also longitudinal photons are possible.

4. For general condensed matter systems one can have also optical phonons for which the polarization is orthogonal to the wave vector and these could couple to ordinary photons. The motion of the charged particles in the electromagnetic field of massless extremal (topological light ray) would be a situation in which phonons and photons accompany each other. This would make possible the piezo-electric mechanism.

Under these assumptions the collections of audible frequencies could also represent passwords activating the intronic portion of the genome and lead to gene expression or some other activities. If one believes on the hypothesis that DNA acts like topological quantum computer based on the braid strand connections between nucleotides in the intronic portion of DNA with the lipids of the nuclear and/or cell membranes, also topological quantum computation type processes could be activated by the collections of sound frequencies [K5].

What distinguishes speech and music from sounds without meaning?

Speech and music ares very special form of sound in that they have direct meaning. The more one thinks about these facts, the more non-trivial they look. For music - say singing - the frequency of the carrier wave is piecewise constant whereas for speech it remains constant and the amplitude modulation is important. In fact, by slowing down the recorded speech, one gets the impression that carrier frequency is actually modulated like in chirp (frequency goes down and covers a range of frequencies). What is the mechanism giving to speech and music its meaning and in this manner distinguishes them from other sounds?

Besides the frequency also phase is important for both speech and music experience. Speech and reverse speech sound quite different the intensity in frequency space is same. Therefore the relative phases associated with the Fourier coefficients of various frequencies must be important. For music simple rational multiples of the fundamental define the scale. Could it be that also the frequencies relevant to the comprehension of speech correspond to these rational multiples?

Suppose that one indeed believes on the proposed vision based on the fundamental role of negentropic entanglement in generation of meaning and takes seriously the proposed mechanisms for generating it. Can one understand why music and speech differ from general sounds and what distinguishes between them?

1. With these assumptions suitable collections of frequencies sound wave would indeed activates the intronic portion of DNA by generating negentropic entanglement. Also other dark flux tubes than those assignable to DNA are involved. For instance, hair cells responsible for hearing of sounds around particular frequencies could involved flux tubes and utilize similar mechanism. Allowing only hair cells would define the conservative option. On the other hand, one could well claim that what happens in ear has nothing to do with the understanding of the speech and music, it could take place only at the level of neuronal nuclei.

2. Could the direct interaction of sound waves with magnetic flux tubes generate the experiences of speech and music? In other words, assign meaning to sounds? The criterion for sound to have an interpretation as speech or music would be that it contains the resonance frequencies needed to activate the DNA, or more generally generate dark super currents generating Cooper pairs in this manner loading metabolic energy storages. This would apply to both speech and musical sounds.

3. The pitch of the speech and musical sound can vary. We are aware of the key of the music piece and of modulations of the key and remember the starting key, and it is highly satisfactory to make a return to "home" defined by the original key. This would imply that the overall scale of the collection of frequencies can be varied and that the pitch of the speech defines a natural expectation value of this scale. For persons possessing so called absolute ear this scaling symmetry would be broken in a well-defined sense.

4. Musical scales involve frequencies coming as rational multiples of the basic frequency. Octaves - power of two multiples- of the frequency can be said to be equivalent as far musical experience is considered. One might understand the special role of rational multiples of the basic frequency if the Fourier components have same phase periodically so that the experience is invariant under discrete time translations. This requires commensurable frequencies expressible as rational multiples of the same fundamental frequency. The preferred role of p-adic primes comings as powers of two could relate to the octave phenomenon.

5. Are the relative phases of different Fourier components important for music experience? If one requires a periodical occurrence of maximal possible intensity (maximal constructive interference) then the relative phases must vanish at the values of time for maximal possible intensity. What seems essential that the presence of commensurate frequencies gives rise to time translation invariant sensation whereas speech consists of pulses.

Are speech and music quantum duals like position and momentum?

Frequencies are crucial for music experience. In the case of of speech the relative phases are very important as the example of reverse speech demonstrates. How a given phoneme is heard

is determined to high degree by the frequency spectrum in the beginning of the phoneme (this distinguishes between consonants). Vowels are nearer to notes in vocalization. Speech consists of pulses and destructive interference between different frequencies is required to generate pulses and different pulse shapes so that phase information is important. At least the harmonics of the basic rational multiples of the fundamental are necessary for speech.

One can criticize the previous discussion in that it has been completely classical. Phase and frequency are in wave mechanics canonically conjugate variables analogous to position and momentum. Is it really possible to understand the difference between music and speech purely classically by assuming that one can assign to sound waves both frequencies and phases simultaneously - just like one assigns to a particle sharp values of both momentum and position? Or should one use either representation either in terms numbers of phonons in different modes labelled by frequencies or as coherent states of phonons with ill defined phonon numbers but well defined amplitudes? Could the coherent states serve as the analogs of classical sound waves. Speech would be as near as possible to classical sound and music would be quantal. Of course, there is a large variety of alternative choices of basis states between these two extremes as a specialist in quantum optics could tell.

Suppose that this picture is more or less correct. What could be the minimal scenario allowing to understand the differences between speech and music?

1. Only a subset of frequencies could activate DNA (or if one wants to be conservative, the hair cells) also in the case of speech. One could still pick up important frequencies for which the ratios are simples rational numbers as in the case of musical scale plus their harmonics If this assumption is correct, then speech from which all frequencies except for the harmonics of the simple rational multiples of the fundamental are removed, should be still be comprehensible as speech. The pitch of the speech would determine a good candidate for the fundamental frequency.

2. The harmonics of frequencies activating DNA would be crucial for speech. Harmonics are present also in music and their distribution allows to distinguish between different instruments and persons. The deviation of musical notes from ideal Fock states would correspond to this.

3. The naïve guess is that the simple rational multiples of fundamental and the possibility of having their harmonics could be reflected in the structure of intronic portions of DNA as repetitive structures of various sizes. This cannot be the case since the wavelengths of ordinary photons would be so small that the energies would be in keV range. Neither is this expected to be the case. It is magnetic flux tubes and sheets traversing the DNA which carry the radiation and the natural lengths assignable to these flux quanta should correspond to the wave lengths. The larger, the flux quantum, the lower the frequency and the larger the value of Planck constant. Harmonics of the fundamental would appear for given flux tube length naturally.

The DNA strands and flux tubes and sheets form a kind of electromagnetic music instrument with flux quanta taking the role of guitar strings and DNA strands and other structures such as lipids and possible other molecules to which flux tubes get attached taking the role of frets in guitar. This analogy suggests that for wave lengths measured in micrometers the basic frequencies correspond to the distances between "frets" defined by cell and nuclear membranes in the tissue in the scale of organism. This would relate the spectrum of resonance frequencies to the spectrum of distances between DNAs in the tissue.

For wave lengths corresponding to very large values of Planck constant giving rise to frequencies in VLF and ELF range and corresponding also to audible frequencies, the preferred wave lengths would correspond to lengths of flux quanta in Earth size scale. One should understand whether the quantization of these lengths in simple rational ratios could take place for the preferred extremals.

4. Could the pulse shape associated with massless extremals (MEs, topological light rays) allow to distinguish classically between speech and music at the level of space-time correlates? Linear superposition of Fourier components in the direction of ME is possible and this allows to speak about pulse shape. It allows also the notions of coherent state and Fock state for

given direction of wave vector. Essential would be the restriction of the superposition of fields in single direction of propagation to be distinguished from the superposition of the effects of fields associated with different space-time sheets on multiply topologically condensed particle. Maybe this would allow to make testable predictions.

2.6   Pythagoras, Music, Sacred Geometry, And Genetic Code

The conscious experiences generated by music demonstrate a fascinating connection between algebra and emotions. How can major and minor scale using different frequency ratios generate so different emotional experiences. This strongly suggests the we experience music as entire time interval, 4-D patterns - rather than time=constant snapshots. Also the ability remember the key and the tension lasting as long as the return to the basic key has not taken place, is example of this. One of the key questions is why octaves - that is powers of 2 of the basic note of the scale - are experienced as equivalent? One can also wonder what is behind consonance and dissonance.

I have already earlier tried to understand music experience and considered some ideas inspired by p-adic numbers fields - such as the idea that Pythagorean scale coming as powers of 3 for the basic note modulo octave equivalence might relate to 3-adicity. Reading of a book titled "Interference: A Grand Scientific Musical Theory" by Richard Merrick [J112] freely available in web (`http://tinyurl.com/8d2hfka`) re-stimulated my interest. In particular, I found the idea about a connection between music scale and harmonies with Platonic solids (3-D "sacred geometry") as highly inspiring. The basic question was whether the 12-tone scale could be mapped to a curve going once through each point of icosahedron having 12 vertices and whether the 20 faces of icosahedron, which are triangles could define the basic chords in 12-tone scale. These curves are known as Hamiltonian cycles and in the case of icosahedron there are 2^{10} of them: those obtained from each other by rotation leaving icosahedron invariant are however equivalent.

A given triangle of icosahedron can contain 0, 1 or 2 edges of the cycle and the numbers of the triangles corresponding to these triangle types classify partially the notion of harmony characterized by the cycle. Quint cycle suggests the identification for the single edge of curve as quint interval so that triangles would represent basic 3-chords of the harmony with 0, 1, or 2 quints.

One can make same questions also for other Platonic solids- tetrahedron (4 vertices), octahedron and cube which are duals of each other and have (6 and 8 vertices respectively, and dodecahedron which is dual of icosahedron having 20 vertices and 12 faces. Arabic music uses half intervals and scales with 19 and 24 notes are used. Could 20-note scale with harmony defined by 5-chords assigned to the pentagons of dodecahedron have some aesthetic appeal? Nowadays it is possible to develop electronically music based on this kind of scale and this kind of experimentation might be a fascinating intellectual and artistic adventure for a young composer.

I have also played with the idea that the 20 amino-acids could somehow correspond to the 20 triangles of icosahedron. The combination of this idea with the idea of mapping 12-tone scale to a Hamiltonian cycle at icosahedron leads to the question whether amino-acids could be assigned with the equivalence class of Hamiltonian cycles under icosahedral group and whether the geometric shape of cycle could correspond to physical properties of amino-acids [I28]. The identification of 3 basic polar amino-acids with triangles containing no edges of the scale path, 7 polar and acidic polar amino-acids with those containing 2 edges of the scale path, and 10 non-polar amino-acids with triangles containing 1 edge on the scale path is what comes first in mind.

The number of DNAs coding for a given amino-acid [I14] could be also seen as such a physical property. The model for dark nucleons leads to the vertebrate genetic code with correct numbers of DNAs coding for amino-acids. It is not however clear how to interpret DNA codons geometrically.

It however turns out that one can understand only the role of 60 codons in the icosahedral framework. The treatment of the remaining 4 codons and of the well-known 21st and 22nd amino-acids requires the fusion of icosahedral code with tetrahedral code represented geometrically as fusion of icosahedron and tetrahedron along common face which has empty interior and is interpreted as punct coded by stopping codons. In this manner one can satisfy the constraints on the Hamiltonian cycles, and construct explicitly the icosahedral Hamiltonian cycle as (4, 8, 8) cycle whose unique modification gives (4, 11, 7) icosa-tetrahedral cycle. Remarkably, two months after writing the first version of the article I learned that the data needed to calculate the Hamiltonian cycles can be found from web and that (4, 8, 8) cycle allows at least two realizations whereas

the original candidate (3, 10, 7) allows no realization with symmetries but could do so with no symmetries.

2.6.1 Could Pythagoras Have Something To Give For The Modern Musicology?

The ideas of Pythagorean school about music were strongly based on the number theory of that time. So called modern approaches tend to seem music scales as cultural phenomena. There are however many reasons to suspect that Pythagorean school might have been much nearer to truth.

Pythagoras and transition from rational numbers to algebraic numbers

Pythagoras was one the greatest ancient mathematicians. The prevailing belief at that was that the world can be described solely in terms rational numbers. During the times of Pythagoras the ancient mathematical consciousness had entered at the verge of a profound revolution: the time had become ripe for the discovery of algebraic numbers expanding rational numbers to an infinite series of algebraic extensions of rationals containing also rational multiples for finite number of algebraic numbers emerging as roots of polynomials with rational coefficients. Euclid introduces square root geometrically as length of the diagonal of square. In ancient India it was discover 800-500 BC, possibly much earlier. Unfortunately, the emergence of Christianity stopped the evolution of mathematics and new progress began at times of Newton when also reformation took place.

The well-known but story (good story but probably not true) tells that a pupil of Pythagoras demonstrated that the diagonal of unit square ($\sqrt{2}$) cannot be rational number and had to pay with his life for the discovery. Pythagoras himself encountered $\sqrt{2}$ through music theory. He asked what is the note exactly in the middle of the of the scale. Modern mathematician would answer half of octave corresponding to the frequency ratio $2^{1/2}$. Algebraic numbers did not however belong to the world of order of Pythagoras and he obtained to a non-satisfactory rational approximation of this number. This was very natural since only rational approximations of algebrais are possible in the experimental approach using only strings with rational number valued lengths. $\sqrt{2}$ represents the interval $C - F_{\#}$ known as tritone and this this interval was associated with devil and its use was denied also by church. Only after reformation $\sqrt{2}$ was accepted and this interval appears repeatedly in the compositions of Bach.

The amazing connections between evolution of mathematics and evolution of the religious beliefs inspires the question whether the evolution of consciousness could at basic level correspond to th evolution of the complexity of the number field behind the dynamics underlying consciousness. For instance, in TGD framework the vision about physics as generalized number theory allows one can to ask whether the mathematical evolution could have meant quite concretely the emergence of increasingly algebraic extensions of rationals for the coefficients of polynomials describing space-time surfaces serving as space-time correlates of consciousness.

Pythagoras and music

Pythagoras was both mathematician and experimentalist studying the world of musical experience experimentally. String instruments were his tool. The notion of frequency was not know at the time and length of vibrating part of string was the notion used. The experienced equivalence of notes differing by octave was known at that time and octave equivalence was understood as a fundamental symmetry of music manifesting itself as a scaling-by-2 symmetry for the length of a vibrating string.

Pythagoras developed 8 note scale CDEFGAHC (as a matter fact, 7 notes by octave equivalence) as we know as a combination of two scales EFGA and HCDE using octave equivalence and it was established as the official music scale. Pythagorean scale is expressed solely in terms of rational number valued ratios of the string length to that for the basic note of the scale (ratio of frequency to the fundamental).

Pythagorean scale (`http://tinyurl.com/28cu6j`, `http://tinyurl.com/7mc4ut`) is expressed solely in terms of powers of the ratio 3/2 for lengths of vibrating strings correspond to an interval known and complete fifth (C-G). The series of complete fifths (C-G-D-A...) known as progression by fifths gives very nearly 7 octaves but not quite: $(3/2)^{12} \simeq 128 + 1.75 = 2^7 + 1.745$. It

would have been very natural to build 12-note scale as powers of rational (3/2) or by octave equivalence as powers of 3. The failure to close is very small but people with absolute ear experience the transponation of a melody to different key as dissonant since the frequency ratios do not remain quite same. At the time of Bach (Well tempered Klavier) the equal tempered scale obtained by diving the logarithmic scale to 12 equally long parts emerged and replacing powers of 3/2 with the 12 powers of algebraic number $2^{1/12}$ inside same octave even without octave equivalence emerged.

By octave equivalence Pythagorean scale means that all notes of the scale come in powers of 3 which strongly brings in mind 3-adicity. If one does not use octave equivalence when generalization of p-adicity to q-adicity with $q = 3/2$ is highly suggestive. q-adic numbers do not in general form number field, only an algebra.

Later more complex rational number based representations of scale using octave equivalence have been developed. The expression of the frequency ratios of the notes of the scale in terms of harmonic of fundamental modulo octave equivalence and involving only integers consisting of primes 2, 3, 5 is known as just intonation (`http://tinyurl.com/7mc4ut`).

1. Music and Platonic solids

Pythagoras was also aware of a possible connection between music scales and Platonic solids. Pythagoras is claimed to have discovered tetrahedron, hexahedron (cube) and dodecahedron while octahedron and icosahedron would have been documented by greek mathematician Thaletus two hundred years later. The tetrachord and was assigned with tetrahedron and one and imagined that Pythagorean scale could have been assigned with pair of tetrahedra somehow - cube or octahedron which comes in mind. Note that this would require that basic note and its octave should be regarded as different notes.

These attempts inspire the question whether the mapping music scales to the vertices of Platonic solids could provide insights about music experience. One can also ask whether there might be a mapping of music understood as melodies and chords in some scale to the geometries defined by Platonic solids.

1. Since 12-note scale is used in practically all classical western music and even in atonal music based on 12-note scale, the natural question is whether 12-note scale could be mapped to a connected, closed, non-self-intersecting path on icosahedron going through all 12 vertices and consisting of edges only. Closedness would mean that base note and its octave are identified by octave equivalence.

2. This mathematical problem is well-known and curves of this kind are known as Hamilton cycles and can be defined for any combinatorial structure defined by vertices and faces. Hamilton proved that Hamiltonian cycles (possibly identifiable as 20-note scale) at dodecahedron is unique module rotations and reflection leaving dodecahedron invariant. Also in the case of tetrahedron and cube the Hamiltonian cycle is unique.

3. For octahedron and icosahedron this is not the case [A4] and there are both cycles containing only faces with at least 1 edge of the path and also cycles containing no faces containing no edges of the path. Numerical experimentation is rather straightforward manner to determine Hamiltonian cycles and $H = 2^{10} = 1024$ cycles can be found. The number of topologically non-equivalent cycles (not transformable to each other by the isometries of icosahedron) is factor of this number. The group of orientation preserving isometries of icosahedron is the alternating group A_5 of 60 even permutations of five letters. The full group of isometries is $G = A_5 \times Z_2$ containing $N = 120$ elements.

4. Some subgroup of G leaves given path invariant and its order must be factor M of N so that topological equivalence class of cycles contains $R = N/M$ elements. The number of topologically non-equivalent cycles in given class with $H(top)$ elements is $N_{tot} = H(top)/R$ so that R must be a factor of $H(top)$.

Before continuing it is good so summarize the geometry of icosahedron shortly. There are 20 faces which are triangles, 12 vertices, and 30 edges. From each vertex 5 edges. Therefore the construction of Hamiltonian cycles means that at each vertex on path one must select between four options edges since one cannot return back. This gives $4^{12} = 2^{24} \sim 1.6 \times 10^7$ alternatives to

be considered. Therefore the numerical search should be relatively easy. Keeping account of the points already traversed and not allowing self intersections, the actual number of choices is reduced. The construction requires labeling of the vertices of the icosahedron by integers 1, ..., 12 in some manner and defining 12×12 matrix $A(i,j)$ whose element equals to 1 if vertices are neighbours and 0 if not. Only the edges for with $A(i,j) = 1$ holds true are allowed on the path. A concrete representation of icosahedron as a collection of triangles in plane with suitable identifications of certain edges is needed. This helps also to visualize the classification of triangles to three types discussed below. This can be found in the Wikipedia article (see `http://tinyurl.com/ns9aa`).

2. Numbers of different triangles as characterizers of harmony

A possible interpretation for topologically non-equivalent paths is as different notions of harmony.

1. Proceeding in Pythagorean spirit, the neighboring points would naturally correspond to progression by fifths - that is scalings by powers of 3/2 or in equal temperated scale by powers of $2^{7/12}$. This would mean that two subsequent vertices would correspond to quint.

2. The twenty triangles of the icosahedron would naturally correspond to 3-chords. Triangles can contain either 0, 1, or 1 edges of the 12-edge scale path. The triangle containing 3 edges is not possible since it would reside on a self-intersecting path. A triangle containing one edge of path the chord would contain quint which suggest a chord containing basic note, quint and minor or major third. The triangle containing two edges would contain subsequent quints - CDG is one possible example by octave equivalence. If the triangle contains no edges of the path one can say that the chord contains no quints.

   The numbers of triangles classified according to the number of path edges contained by them serves as the first classification criterion for a given harmony characterized by the Hamiltonian cycle (note that one cannot exclude the possibly of non-closed paths since Pythagorean construction of the scale by quints does not yield quite precisely octave as outcome).

Fig 1. There are 3 different types of triangles characterized by the number of edges contained by them. This predicts chords with 0, 1 or 2 quints.
`http://tgdtheory.fi/appfigures/kolmiot.jpg`

Consider now the situation in more detail.

1. The topologically equivalent cycles must have same numbers of faces containing 0, 1, or 2 edges of the Hamiltonian path since isometries do not change these numbers. Let us denotes these numbers by n_0, n_1 and n_2. The total number of faces is 20 so that one has

$$n_0 + n_1 + n_2 = 20 \ .$$

Furthermore, each of the 12 edges on the path is contained by two faces so that by summing over the numbers of edges associated with the faces one obtains twice the number of edges:

$$0 \times n_0 + 1 \times n_1 + 2 \times n_2 = 2 \times 12 = 24 \ .$$

From these constraints one can solve n_0 and n_1 as function of n_2:

$$n_0 = n_2 - 4 \ , \quad n_2 \geq 4 \ ,$$
$$n_1 = 24 - 2n_2 \ , \quad n_2 \leq 12 \ .$$

If these integers characterize the topological equivalence completely and if the allowed combinations are realized, one would have 12-4=8 topologically nonequivalent paths. The actual number is $N_{tot} = 2^k$, $k \geq 7$, so that the integers cannot characterize the topology of the path completely.

2. The number of Hamiltonian cycles on icosahedron is known to be 2560 [A1]. Numerical calculations [A2] (`http://tinyurl.com/pmghcwd`) shows that the number of Hamiltonian cyclesw with one edge fixed is $2^{10} = 1024$. Here one regards cycles with different internal orientation as different. This would mean that the sum over the numbers $N(n_2)$ if cycles associated with differ values of n_2 satisfies

$$\sum_{n_2=4}^{12} \sum_i N(n_2, i)) = 2^{10} \ .$$

$N(n_2, i)$ is the number of paths of given topology with fixed n_2. The numbers $N(n_2, i)$ are integers which are factors of $N = 120$ of the order of the isometry group of the icosahedron. The average of $N(n_2, i)$ is $2^7 = 128$.

3. Additional topological invariants characterizing the notion of harmony

The interpretation of amino-acids in terms of 20 triangles of icosahedron interpreted as allowed chords for a given notion of harmony leads to a unique identification of the integers n_i as $(n_0, n_1, n_2) = (3, 10, 7)$. The attempt to interpret this "biological harmony" leads to the identification of additional topological invariants characterizing the notion of harmony. It will be assumed that edges correspond to quints. If they would correspond to half-step the chords would contains 0, 1, or 2 subsequent half-intervals which does not conform with the usual views about harmony. In Pythagorean scale quint corresponds to 3/2 and in equal tempered scale quint corresponds to the algebraic number number $2^{7/12}$.

Above the attention was paid to the properties of the triangles in relation to the Hamiltonian cycle. One can consider also the properties of the edges of the cycle in relation to the two neighboring triangles containing it. Restrict first the attention to the biological harmony characterized by $(n_0, n_1, n_2) = (3, 10, 7)$.

Fig. 2. The edge of the cycle belongs to 2 triangles, which as chords can correspond to 1 resp.2, 1 resp. 1 and 2 resp. 2 quints.
`http://tgdtheory.fi/appfigures/sivut.jpg`

1. Everyone of the 12 quints $C-G$, $C_\#-G_\#$, ... would be contained to neighboring triangles tht is 3-chords containing at least one quint. Denote by p_{12}, p_{11} resp. p_{22} denote the number of edges shared by 1-quint triangle and 2-quint triangle, by 2 1-quint triangles, resp. 2 2-quint triangles. Besides $p_{ij} \geq 0$ one has

$$\sum p_{ij} = 12 \ .$$

since the cycle contains 12 edges. There are $p_{12} + 2p_{11} = n_1$ 1-quint triangles and $(p_{12} + 2p_{22})/2 = n_2$ 2-quint triangles (note double counting responsible for division by two). Altogether this gives

$$p_{22} = 12 - p_{11} - p_{22} \ ,$$
$$p_{22} = p_{11} + n_2 - \frac{n_1}{2} \ ,$$
$$p_{22} = n_2 - \frac{p_{12}}{2} \ .$$

2. These three Diophantine equations are for integers and would allow for real numbers only single solution and for integers it in the generic case there are no solutions at all. Situation changes if the equations are not independent which can happen if the integers n_i satisfy additional conditions. By subtracting first and second and second and third equation from each other one obtains the consistency condition

$$n_1 = 24 - 2n_2 \ .$$

This condition is however second of the conditions derived earlier so that only two equations, say the first two ones, are independent.

$$p_{22} = p_{11} + n_2 - \frac{n_1}{2} \quad,$$
$$p_{22} = n_2 - \frac{p_{12}}{2} \quad.$$

giving

$$p_{11} = (n_1 - p_{12})/2 \quad,$$
$$p_{22} = p_{11} + n_2 - \frac{n_1}{2} = n_2 - \frac{p_{12}}{2} \quad.$$

One must have $0 \leq p_{ij} \leq 12$ and $p_{12} \leq n_1$ from $p_{11} = (n_1 - p_{12})/2$. Here one has $p_{12} \in \{0, 2, ... Min\{12, 2n_2, n_1\}$ so that $Min\{7, n_2 + 1, [n_1/2] + 1\}$ solutions are possible. The condition that the cycle has no self-intersections can forbid some of the solutions.

3. The first guess for the "biological harmony" possibly associated with amino-acids would be $(n_0, n_1, n_2) = (3, 10, 7)$: this if one neglects the presence of 21st and 22th amino-acid also appearing in proteins. It turns out that a more feasible solution fuses tetrahedral code and icosahedral codes with $(n_0, n_1, n_2) = (4, 8, 8)$ giving $(n_0, n_1, n_2) = (4, 11, 7)$ for icosatetrahedral code.

   For instance, $(n_0, n_1, n_2) = (3, 10, 7)$ would give $p_{12} \in \{0, 2, 4, 6, 8, 10\}$, $p_{11} \in \{5, 4, 3, 2, 1, 0\}$, $p_{22} \in \{7, 6, 5, 4, 3, 2\}$ so that one has 6 alternative solutions to these conditions labelled by p_{12}. The number of neighboring triangles containing single quint is even number in the range $[0, 10]$: this brings in mind the possibility that the neighboring single quint triangles correspond to major-minor pairs. Clearly, the integer p_{12} is second topological invariant characterizing harmony.

   4. Distribution of different types of edges

   Also the distribution of the 12 edges to these 3-types is an invariant characterizing the shape of the curve and thus harmony as isometric invariant.

   Fig. 3. There are different distributions of edge types characterized by the neighboring triangles of the edge.
   http://tgdtheory.fi/appfigures/jakauma.jpg

1. p_{12} 1-1 edges can be chosen in

$$N(1 - 1, p_{12}) = \begin{pmatrix} 12 \\ p_{12} \end{pmatrix}$$

ways and 1-2 edges in

$$N(1 - 2, p_{12}) = \begin{pmatrix} 12 - p_{12} \\ p_{12} \end{pmatrix}$$

ways. The remaining 2-2 edges can be chosen only in one manner. This gives altogether

$$N(p_{12}) = N(1 - 1, p_{12}) \times N(1 - 2, p_{12})$$

ways for given value of p_{12}.

To summarize, one obtains large number of notions of harmony are possible although one cannot expect that the absence of self-intersections does not allow all topologies for the cycle.

Would you come with me to icosadisco?

This map would allow one-to-one map of the notes of any music piece using icosahedral geometry. If octave equivalence is assumed, a given note would be mapped to a fixed vertex of icosahedron at which lamp is turned on and also to the wavelength of the light in question since visible light spans an octave. Chords would correspond to the turning on of lights for a group of icosahedral points. Icosahedrons with size scaled up by two could correspond to octave hierarchy: for practical purposes logarithmic scale implying that icosahedrons have same distance would be natural as in the case of music experience since piano spans 7 octaves and human ear can hear 10 octaves. Church would nowadays allow icosadiscos to use also half octaves to amplify further the audiovisual inferno effect so characteristic for discos. One could also try to realize special effects like glissandos, vibratos and tremolos.

2.6.2 Connection Between Music Molecular Biology?

Music affects directly emotions, and consciousness is one aspect of being living. This raises the question whether the Platonic geometries might have something to do with basic building bricks of life and with genetic code.

Could amino-acids correspond to 3-chords of icosahedral harmony?

The number of amino-acids is 20 and same as the number of triangular faces of icosahedron and the vertices of dodecahedron. I have considered the possibility that the faces of icosahedron could correspond to amino-acids [K5]. Combined with the idea about connection between music scale and icosahedron this inspires the following consideration.

1. For a proper choice of the mapping of the 12-note scale to the surface of icosahedron the 20 triangles could correspond to 20 amino-acids analogous to 3-chords and that the 3 types of 3-chords could correspond to 3 different classes of amino-acids. One can of course consider also the mapping of amino-acids to a unique sequence of 20 vertices of dodecahedron representing 20-note scale or 20-chord scale and replacement of the 3-chords defining the harmony with 12 5-chords.

2. Amino-acids are characterized by the non-constant side chain and these can be classified to three categories: basic polar, non-polar, and polar (http://tinyurl.com/ycvm6yjs). The numbers of amino-acids in these classes are $a_0 = 3$, $a_1 = 10$, $a_2 = 7$. Could these classes correspond to the numbers n_i characterizing partially some topological equivalence classes of Hamiltonian paths in icosahedron? There is indeed a candidate: $a_0 = n_0 = 3$, $a_1 = n_1 = 10$, $a_2 = n_2 = 7$ satisfies the conditions discussed above. 3 basic polar amino-acids would correspond to the triangles with no edges on the Hamiltonian cycle, 10 non-polar amino-acids to triangles containing one edge, and 7 acidic polar and polar amino-acids to those containing two edges. One can criticize the combination of polar and acidic polar amino-acids in the same class. One can also classify amino-acids to positively charged (3), negatively charged (2) and neutral (15) ones. In this case the condition is however not satisfied. Thus the proposal survives the first test - assuming of a course that these Hamiltonian cycles exist! This has not been proven and would require numerical calculations.

3. As found Hamiltonian paths have also other topological characteristics and they could correspond to physical characteristics and it would be interesting to see what theyh are. To proceed further one should find the total number of the Hamiltonian paths with $n_2 = 7$ and identify the isometries of different topological equivalence class having $n_2 = 7$.

Amino-acid sequences would correspond to sequences of 3-chords. The translation of mRNA of gene to amino-acid sequence would be analogous to the playing of a record. The ribosome complex would be the record player, the amino-acid sequence would be the music, and mRNA would be the record. Hence genes would define a collection of records characterizing the organism.

d	6	4	3	2	1
N	3	5	2	9	2

Table 2.2: The number of amino acids N associated with a given degeneracy d telling the number of DNA triplets mapped to the amino acid in the genetic code. The degeneracies are always smaller than 7 as predicted by the proposed explanation of the Genetic Code.

Can one understand genetic code?

What remains open is the interpretation of genetic code [I14]. DNA triplets would correspond naturally to triangles but why their number is 64 instead of 20. They would be obviously the analogs of written notes: why several notes would correspond to the same chord?

1. Could different DNA triplets coding for the same amino-acid correspond to various octaves of the chord? The most natural expectation would be that the number of octaves so that one would have 3 DNAs would code single amino-acid and stopping codon would correspond to 4 DNAs. It is difficult to understand why some 3-chords could correspond to 6 octaves and one of them only one.

2. Could the degeneracy correspond to the ordering of the notes of the 3-chord? For the 3-chords there are 6 general orderings and 3 cyclic orderings modulo octave equivalence and characterizing by the choice of the lowest note. The simplest assumption would be that the allowed orderings - degeneracies - are characterized by a subgroup of the cyclic group S_3 yielding the allowed permutations of the notes of the chord. The subgroup orders for S_3 are 1, 2, 3, and 6. The allowed degeneracies are 6, 4, 3, 2, and 1 so that this identification fails for $D = 4$.

3. Could the different correspondences between DNA codons and amino-acids correspond to the different topological equivalence classes of $n_2 = 7$ Hamiltonian cycles. This does not seem to be the case. The number of different DNA-amino-acid correspondences obtained by choosing one representative from the set of DNAs coding for a given amino-acid (and not stopping sign) is the product of the numbers $D(a_i)$ coding amino-acid a_i. From **Table 2.2** this number is given by $6^3 \times 4^5 \times 3^1 \times 2^9 \times 1^2 = 3^4 \times 2^{21}$ and clearly much larger than $N = 2^{10}$.

4. Could the different codons coding for codon code for some additional information so that amino-acids would in some aspect differ from each other although they are chemically identical? Here the magnetic body of amino-acid is a natural candidate. This would suggest that the folding pattern of the protein depends on what DNA sequence codes it. This information might be analogous to the information contained by notes besides the frequencies. Durations of notes corresponds is the most important information of this kind: the only candidate for this kind of information is the value of $h_{eff} = n \times h$ associated with the amino-acid magnetic body determining its size scale. Magnetic fields strength could be also code by DNA codon besides amino-acid.

Second question concerns genetic code itself. Could the DNA degeneracies $D(a_i)$ (number of DNAs coding for amino-acid a_i) be understood group theoretically in terms of icosahedral geometry? The triangles of the icosahedron are mapped the triangles under the isometries.

1. One can start by looking the **Table 2.2** for the genetic code telling the number $N(d)$ of amino-acids coded by d DNA codons. One finds that one can divide DNAs to three groups containing $n = 20$, $n = 20$, resp. $n = 21$ codons.

   (a) There are 3 amino-acids codes by 6 codons and 2 amino-acids coded by 1 DNA: $3 \times 6 + 2 \times 1 = 20$ codons altogether.
   Note: One could also consider 1 amino-acid coded by 2 codons instead of 2 coded by 1 codon $3 \times 6 + 1 \times 2 = 20$.

   (b) There are 5 amino-acids coded by 4 codons making $5 \times 4 = 20$ codons altogether.

(c) There are 9 amino-acids coded by 2 codons and 1 by 3 codons making $9 \times 2 + 1 \times 3 = 21$ codons.
Note: One could also consider the decomposition $8 \times 2 + 2 \times 1 + 1 \times 3 = 21$ codons implied if 1 amino-acid is coded by 2 codons in the first group.

This makes 61 codons. There are however 64 codons and 3 codons code for stopping of the translation counted as punct in the table.

1. This would suggest the division to $60 + 4$ codons. The identification of additional 4 codons and corresponding amino-acids is not so straightforward as one might first think. 3 of the 4 additional codons could code for punct (Ile) and 1 of them to Ile (empty amino-acid).

2. What suggests itself strongly is a decomposition of codons in 3 different ways. 3 groups of 6 codons plus 2 groups of 1 codon (1 group of 2 codons), 5 groups of 4 codons, and 10 groups of 2 codons (9 groups of 2 codons plus plus 2 groups of 1 codon).

This kind of decompositions are induced by the action on the triangles of icosahedron by three subgroups of the isometry group $A_5 \times Z_2$ of the icosahedron having $120 = 2 \times 2 \times 2 \times 2 \times 3 \times 5$ elements and subgroups for which number of elements can be any divisor of the order. The orbit associated with a subgroup with n elements has at most n triangles at its orbit. This allows immediately to deduce the values of n possibly explaining the genetic code in the proposed manner.

1. The 3 amino-acids coded by 6 codons must correspond to $n = 6$. This subgroup must have also two 1-element orbits (1 2-element orbit): in other words, 2 triangles must be its fixed points (form its orbit).

    (a) The non-abelian group S_3 permuting the vertices of is the first candidate for the subgroup in question. The triangles at the opposite sides of the icosahedron remain invariant under these permutations. S_3 however has two orbit consisting of 3 triangles which are "wall neighbours" of the triangles which remains fixed.

    (b) Second candidate is the abelian group $\tilde{Z}_2 \times Z_3$. Here Z_3 permutes the vertices of triangle and $\tilde{Z}_2$ is generated by a reflection of the triangle to opposite side of icosahedron followed by a rotation by π. This group has 3 orbits consisting of 6 triangles and 1 orbit consisting of 2 triangles (the triangles at opposite side of icosahedron). This group seems to be the only working candidate for the subgroup in question.

2. The 5 amino-acids coded by 4 codons must correspond to $n = 4$ and therefore to $\tilde{Z}_2 \times Z_2$. This is indeed subgroup of icosahedral group which permutes triangles at the vertices of inscribed tetrahedron. Now all orbits contain 4 triangles and one must have 5 orbits, which are obtained by acting on the 5 triangles emanating from a given vertex. Note that also Z_5 is subgroup of icosahedral group: this would give a variant of code with 4 amino-acids coded by 5 codons if it were possible to satisfy additional consistency conditions.

3. Consider next the group consisting of 9 amino-acids coded by 2 codons and Ile ("empty" amino-acid) coded by 3 codons. Since only the $\tilde{Z}_2 \times Z_3$ option works, this leaves 9 amino-acids coded by 2 codons and 2 amino-acids coded by 1 codon. The subgroup must correspond to $n = 2$ and thus Z_2 acting on fixed triangle and leaving it and its $\tilde{Z}_2$ image invariant. One has 9 2-triangle orbits and two single triangle orbits corresponding to the triangles at opposite sides of the icosahedron. The 9 amino-acids coded by 2 codons are all real or 8 of them are real and 1 corresponds to "empty amino-acid" coded by two codons.

3-element orbits are lacking and this forces to consider a fusion of of icosahedral code with tetrahedral code having common "empty-acid" - common triangle of icosahedron and tetrahedron) coded by 2 icosahedral codons and 1 tetrahedral codon. Ile would be coded by 3 codons assignable to the orbit of Z_3 subgroup of tetrahedral symmetry group S_3 and would be associated with the tetrahedron. This would predict 2 additional amino-acids which could be understood by taking into account 21st and 22nd amino-acid (Sec and Pyl [I28]).

The Hamiltonian cycle is not explicitly involved with the proposed argument. Some property of the cycle respected by the allowed isometries might bring in this dependence. In Pythagorean

spirit one might ask whether the allowed isometries could leave the Hamiltonian cycle invariant but move the vertices along it and induce a mapping of faces to each other.

The amino-acid triangle at given orbit cannot be chosen freely. The choices of amino-acid triangles associated with the three groups of 20 DNAs must be different and this gives geometric conditions for the choices of the three subgroups and one can hope that the assignment of amino-acid toa given triangle is fixed about from rotational symmetries.

Does the understanding of stopping codons and 21st and 22nd amino-acids require fusion of tetrahedral and icosahedral codes?

Several questions remain. Could one also understand the additional 4 DNA codons? Could one understand also how one of them codes amino-acid (Ile) instead of stopping codon? Can one related additional codons to music?

1. Attachment of tetrahedron to icosahedron as extension if icosahedral code

The attachment of tetrahedron to icosahedron allows to understand both stopping codons and punct as well as the 21st and 22nd amino-acids geometrically.

1. Something is clearly added to the geometric structure, when at least 4 additional DNA codons and 2 amino-acids are brought in. The new codons could represent orbits of faces of Platonic solid with 4 faces representing punct and 3 real amino-acids: say Ile, Pyl, and Sec. The 4 faces should be triangles and actually must be so since tetrahedron is the only Platonic solid having 4 faces and its faces are indeed triangles. Tetrahedron has symmetry group S_3 containing Z_3 and Z_2 as subgroups. Z_3 leaves one of the tetrahedral triangles invariant so that one has two orbits consisting of 1 and 3 triangles respectively.

2. One amino-acid is coded by 3 rather than only 2 codons. One can indeed understand this symmetry breaking geometrically. Suppose that the tetrahedron is attached on icosahedron along one of its triangular faces and that this icosahedral face corresponds either Ile or punct coded by 2 icosahedral codons. This face remains also fixed by the action of Z_3 and S_3 subgroups of tetrahedron so that 1 tetrahedral codon codes also for the amino-acid in question.

3. The three other faces of tetrahedron r should bring in three additional amino-acids. punct could correspond to either one of them or to the common base triangle which is indeed geometrically in unique position. One could even demand that this triangle is "empty" so that tetra-icosahedron would be non-singular continuous manifold. The 3-triangle orbit outside the icosahedron would correspond to Ile and base triangle to empty amino-acid. Base triangle would be coded by 1 tetrahedral codon plus 2 icosahedral codons.

4. One of the outsider triangles would thus corresponds to Ile but two other triangles to two new exotic amino-acids. In some species there indeed are 21st and 22nd amino-acids (seleno-cysteine (Sec) and pyrrolysine (Pyl), `http://tinyurl.com/2byr2b`) with sulphur replaced with selene. This modification does not change the polarity properties of cys and lys: cys and thus Sec is non-polar and lys and thus Pyl is basic polar implying $(n_0, n_1, n_2) = (3, 10, 7) \rightarrow (4, 11, 7)$.

5. The two other outsider tetrahedral triangles could correspond to the orbits of Z_2 subgroup of S_3 acting as reflection with respect to median of the base triangle. Outside faces form orbits consisting of 1 triangle and 2-triangles. Could these orbits correspond to 21st and 22nd amino-acids coded by 1 and 2 exotic codons?

   Since Ile and Sec are non-polar, they can correspond to 1-quint triangles at tetrahedron. 2-quint triangle cannot however correspond to Pyl which should correspond 0-quint triangle. Hence the 0-quint triangle must be at the isosahedron and the 2-quint triangle must correspond to basic polar amino-acid coded by single codon: Tyr is the only possible option). Hence the tetrahedral amino-acids are fixed to be Ile, Sec, and Tyr and Pyl must correspond to some icosahedral amino-acid.

The second implication is that the icosahedral Hamiltonian cycle from which the icosatetra-hedral cycle is obtained as deformation must correspond to (4, 8, 8) since one cannot deform (3, 7, 10) in such a manner that one would obtain one additional 0-quint triangle.

It should be noticed that the 2 exotic amino-acids are coded by codons which are usually interpreted as stopping codons. Something must however distinguish between standard and exotic codings. Is it "context" giving different meaning for codons and perhaps characterized by different magnetic bodies of codons [K88] ?

Fig. 4. tetra-icosahedron is obtained by attaching tetrahedron along one of its faces to icosahedron. The resulting structure is topological manifold if the common face is replaced with empty set and it is natural to identify it as punct.
http://tgdtheory.fi/appfigures/tetra-icosahedron.jpg

2. How the icosahedral Hamiltonian cycle is modified?

The properties of exotic amino-acids give constraints on how the modification of the Hamiltonian cycle should be carried out. The naïve expectation that the outer triangles of added tetrahedron correspond to punct and 2 exotic amino-acids is not correct. A more appropriate interpretation is as a fusion of icosahedral and tetrahedral codes having common "empty amino-acid" coded 2 icosahedral and 1 tetrahedral 1 stopping codons respectively and obtained by gluing these Platonic solids together along the triangle representing the "empty" amino-acid. That the common triangle corresponds to punct means geometrically that its interior is not included so that the resulting structure is continuous manifold having topology of sphere.

Consider now the detailed construction.

1. One should be able to modify the icosahedral Hamiltonian cycle so that the numbers (n_0, n_1, n_2) charactering icosahedral cycle change so that they conform with the properties of the two exotic amino-acids. Selenocystein (Sec) is nonpolar like cys and pyrrolysine (Pyl) basic polar like Lys so that $(4, 11, 7)$ seems to be the correct characterization for the extended system. One must have $(n_0, n_1, n_2) \rightarrow (4, 11, 7)$.

2. One must visit the additional vertex, which means the replacement of one edge from the base triangle with wedge visiting the additional vertex. There are several cases to be considered depending on whether the base triangle is 1-quint triangle or 2-quint triangle, and what is the type of the edge replaced with wedge. One can even consider the possibility that the modified cycle does not remain closed.

   If the icosahedral cycle has $(n_0, n_1, n_2) = (3, 10, 7)$, the value of n_2 is not changed in the construction. For a closed cycle edge is replaced with wedge and the only manner to preserve the value of n_2 is that the process producing 1 tetrahedral 2-quint triangle transforms 1 icosahedral 2-quint triangle identified as base triangle to 1-quint triangle. If the replaced edge of base triangle is of type 2-1, one has $n_1 \rightarrow n_1 + 1$ since one icosahedral 1-quint triangle disappears and 2 tetrahedral ones appear. Icosahedral n_0 increases by 1 units. Hence the condition $(3, 10, 7) \rightarrow (4, 11, 7)$ would be met. It however seems that $(4, 8, 8)$ is more promising starting cycle as the argument below shows.

3. The number options is at most the number n_2 of 2-quint triangles serving as candidates for punct. An additional condition comes from the requirement that replaced edge is of type 2-1.

Fig. 4. tetra-icosahedron is obtained by attaching tetrahedron along one of its faces to icosahedron. The resulting structure is topological manifold if the common face is replaced with empty set and it is natural to identify it as punct.

Fig. 5. The modification of $(4, 4, 8)$ icosahedral Hamiltonian cycle consistent with the constraints that icosatetrahedral cycle corresponds to $(4, 11, 7)$ consistent the classification of amino-acids in three classes.
http://tgdtheory.fi/appfigures/tetraikosahedroni.jpg

3. Direct construction of Hamiltonian cycle corresponding to bio-harmony

Consider bio-harmony as an example about Hamiltonian cycle taking seriously the extension of the genetic code. I have made very many unsuccessful triangles starting from the assumption that icosahedral cycle satisfies $(n_0, n_1, n_2) = (3, 10, 7)$, and the following proposal starts from different icosahedral cycle. The following is just a trial, which should be checked by a direct calculation.

1. The most obvious guess for the cycle to be modified to cycle at tetra-icosahedron having $(n_0, n_1, n_2) = (4, 11, 7)$ (the triangle corresponding to "empty" amino-acid (to be called punct) is not counted) is $(n_1, n_2, n_3) = (3, 10, 7)$. I have not found cycle with these characteristics.

2. It seems however possible to find cycle with $(n_1, n_2, n_3) = (4, 8, 8)$. From this can obtain the desired kind of extended cycle if the "empty" triangle is 2-quint triangle and the edge replaced with the wedge is of type 2-2. The replacement of icosahedral edge eliminates two icosahedral 2-quint triangles and generates 1 tetrahedral 2-quint triangle giving $n_2 \to n_2 - 2 + 1 = n_2 - 1 = 7$. The disappearance of the icosahedral edge generates two icosahedral 1-quint triangles of which second one corresponds to empty amino-acid and is not counted and 2 tetrahedral 1-quint triangles giving $n_1 \to n_1 + 3 = 11$.

The figure below represents the construction of cycle $(4, 8, 8,)$. The icosahedron is constructed from regions $P(I)$ glued to the triangle t along one edge each. The arrows indicate that the one pair of edges of type 1 and 2, 1 and 3 and 3 and 2 are identified. Also the long edges I of T are identified with pairs of subsequent edges of $P(I)$ as the arrows indicate.

Fig. 6. A proposal for a Hamilton cycle realizing bio-harmony $(n_1, n_2, n_3) = (4, 8, 8)$ allowing extension to cycle $(3, 11, 7)$ on tetra-icosahedron. Circled "0", "1" and "2" indicates whether a given small triangle is 0-, 1-, or 2-quint triangle. It is relatively easy to verify that the condition $(n_1, n_2, n_3) = (4, 8, 8)$ for bio-harmony is satisfied.
`http://tgdtheory.fi/appfigures/aikosahedroni.jpg`

4. Stopping codons and music

What could be the interpretation of the attached tetrahedron in terms of music harmony?

The attachment of tetrahedron means addition of an additional note to the 12-note scale. The scale constructed in Pythagorean spirit identifying quint as scaling by 3/2 contains the 12th note as scaling by $(3/2)^{12}$ of the basic frequency modulo octave equivalence. This is slightly more than scaling by 2^7 so that exact octave is not obtained. The attempt to solve this problem has lead to scales in which one allows a pair of notes with a very small interval between them - say $G_\#$ and A_b being regarded as different notes.

This suggests that the outsider vertex of the attached tetrahedron corresponds to a note very near to some note of the 12-note scale. Which note is in question depends on which of the 10 1-quint triangles is chosen as the base triangle. This is expected to imply additional refinements to the notion of bio-harmony. 2 or three additional 3-chords emerge depending on whether empty amino-acid is interpreted as a real chord.

5. Geometric description of DNA-amino-acid correspondence

The mathematical structure which suggests itself is already familiar from some earlier attempts to understand genetic code [K52]. For icosahedral part of code one would have a discrete bundle structure with 20 amino-acids defining the base space and codons coding the amino-acid forming the fiber. The number of points in the fiber above based point depends on base point and is the number of codons coding the corresponding amino-acid. A discrete variant of singular fiber bundle structure would be in question.

Forgetting for a moment the 4 troublesome codons, the bundle would be the union of the orbits associated with groups S_3, Z_4 and Z_2 of icosahedral group, and the base would consist of 20 amino-acids, one for each orbit. The point of orbit must be selected so that the selections for orbits of two different groups are different.

The addition of the additional codons, punct and two exotic amino-acids would mean gluing of tetrahedron along one of its faces to icosahedron. This would induce extension of the singular

bundle like structure. To each of the new faces one would attach the orbit of triangles representing the codons coding for the corresponding amino-acid.

   To sum up, in its strongest form the model makes several purely mathematical predictions, which could easily kill it.

1. The identification of the 3-chords assignable to the triangles of the icosahedron.

2. The existence of $n_2 = 7$ Hamiltonian cycle requiring however the lumping of acidic polar and polar amino-acids in the same class.

How could one construct the Hamiltonian cycles on icosahedron with a minimal computational work?

Although the construction of Hamiltonian cycles is known to be an NP hard problem for a general graph, one can hope that in case of Platonic solids having high symmetries, a direct construction instead of straightforward numerical search might work. The followingis a proposal for how one might proceeed. It relies on paper model for icosahedron.

1. The basic observation about one can get convinced by using paper model is following. One can decompose the surface of icosahedron to three regions $P(I)$, $I = 1, 2, 3$, with pentagonal boundary and containing 5 triangles emanating from center vertex plus one big triangle T containing 4 pentagonal triangles and one lonely small triangle t opposite to it. These 5 regions span the surface of icosahedron. There is clearly a symmetry breaking and there is great temptation to assume that t corresponds to the triangle along which the tetrahedron is glued to the icosahedron in the model of genetic code realizing the modification of $(3, 7, 10)$ bio-harmony.

2. The Hamiltonian cycle must visit at the centers of each $P(I)$: one enters pentagonal region $P(I)$, $I = 1, 2, 3$ along one of the five interior edges beginning at pentagonal vertex $a_{I,i}$, $i = 1, .., 5$ and leaves it along second edge ending at vertex $b_{I,j}$, $j \neq 5$. One can call these edges interior edges. The edges at boundaries of $P(I)$ can be called boundary edges. Interior edge can correspond to $|i - j| = 0, 1$ or $i - j > 1$. For $|i - j| = 1$ the interior edge gives rise to 2-quint triangle. For $i - j = 0$ there is no boundary edge after $b_(I, j)$.

3. Pentagonal boundary edges come in three types. 2 of them are shared with T, 1 with t opposite to it, and 2 with another pentagonal region $P(I)$. One can label $P(i)$ in such a way that the $P(I)$ shares two boundary edges with $P(I + 1)$.

   The boundary edges of small and big triangle are boundary edges of the 3 pentagonal regions so that they are not counted separately.

4. One can assume that the cycles begins from a vertex of T. Since the cycle is closed it returns back to this vertex. The last edge is either at the boundary of T or goes through one or two edges of the small interior triangle of T so that this triangle is either 0-, 1- or 2-quint triangle.

   t can be 0-, 1-, or 2-quint triangle.

5. The total number of the interior edges inside the 3 pentagonal regions is $3 \times 2 = 6$ so that 6 remaining edges must be boundary edges associated with $P(I)$ and interior edges of T: otherwise one would visit some pentagonal center twice and self-intersection would occur. The boundary edges associated with t and T are boundary edges of $P(I)$, $I = 1, 2, 3$

6. At the vertex $b_(I, j)$ of pentagonal region one must turn right or left and move along the boundary edge. One can move at most $n_I = 4 - j$ boundary edges along the pentagonal boundary in clockwise direction and $n_I = j - 2$ edges in counterclockwise direction (clockwise is the direction in which the index labelling 5 vertices grows). The maximum number of boundary edges is 3 and obtained for $j - i \pm 1$.

7. The condition $\sum n_I + n(T) = 6$, where $n(T) = 1, 2$ is the number of interior edges of T, holds true so that one has $\sum n(I) \equiv n_{tot} \in \{4, 5\}$. The numbers and types (shared with pentagon,

T, or t) of the boundary edges of $P(I)$, the differences $\Delta(I) = j_I - i_I$, the number of edges in t and the number of interior edges of T characterize the Hamiltonian cycle besides the condition that it is closed. The closedness condition seems possible to satisfy. One must enter big triangle through one of the vertices of T and this vertex is uniqely determined once the third pentagon is fixed. One can therefore hope that the construction gives directly all the Hamiltonian cycles with relatively small amount of failed attempts, certainly dramatically smaller than $n = 2^{24} \sim 10^7$ of blind and mostly un-succesful trials.

8. Each $P(I)$ containing boundary edges gives rise to least 2 2-quint triangles associated with $b_I(I)$ and a_{I+1}.

   If all 3 $P(I)$ have $|i-j| > 1$, one has $n_2 = 3 \times 2 = 6$. The contribution of regions $P(I)$ is larger if some pentagon interiors have $|\Delta(I)| = |j(I) - i(I)| = 1$. $|j(I) - i(I)| = 1$ gives $\Delta n_2(I) = 1$ and $\Delta n_1(I) = 0$ since 2 1-quint triangles are replaced with single 2-quint triangle.

   The interior of the T can give 1 2-quint triangle.

9. The number n_1 of 1-quint triangles can be estimated as follows.

   (a) Each pentagonal interior edge pair leading from $a(I,j)$ to $b(I,j)$ contributes 2 1-quint triangles for $\Delta(I) \neq \pm 1$, otherwise one obtains only 1 2-quint triangle. This would give maximum number of 6 1-quint triangles associated with the interior edges of 3 pentagons.

   (b) $P(I)$ pentagonal boundary edges contribute $2 \times (P(I) - 1)$ additional 1-quint triangles.

   (c) T contributes at most 4 1-quint triangles.

   (d) t can correspond 1-quint triangle and would do so if the interpretation of extended code is correct.

10. The construction also breaks the rotational symmetry since the decomposition of icosahedron to regions is like gauge fixing so that one can hope of obtaining only single representative in each equivalence class of cycles and therefore less than 2^{10}. By the previous argument related to icosatetrahedral code, t and the triangle opposite to it cannot however correspond to amino-acids coded by 1 codon as one might guess first. Rather, t corresponds to punct and to 1-quint triangle belonging to Z_2 orbit.

The number of cycles should be 2^{10}. One can try to estimate this number from the construction. Each $b_{I,j}$ can be chosen in 4 ways at the first step but at later steps some vertices of the neighboring pentagon might have been already visited and this reduces the available vertices by $n + 1$ if n subsequent edges are visited. At each vertex $b_{I,j}$ one has 4 options for the choice of the boundary edges unless some boundary edges of pentagon (shared with other pentagons) have been already visited. It is also possible that the number of boundary edges vanishes. One can start from any vertex of triangle. This gives the upper bound of 2^4 choices giving $N < 2^{12}$ paths going through 4 pentagon-like regions. The condition that the path is closed, poses constraints on the edge path assignable to T but the number of choices is roughly 24. The condition that path goes through all vertices and that no edge is traversed twice must reduce this number to 2^{10}.

The numerical construction of Hamiltonian cycles should keep account about the number of vertices visited and this would reduce the number of candidates for $b(I,j)$ and for the choices of $P(I)$ for $I > 1$ as well as the number of edge paths associated with T.

Icosahedral Hamiltonian cycles numerically

A couple of months after writing the article I decided to look at the numerical problem of calculating the Hamiltonian cycles for icosahedron. Recall that the earlier source [A2] (`http://tinyurl.com/pmghcwd`) telling that there are 2^{10} different Hamiltonian cycles when orientation is taken into account and one edge is fixed: if orientation does not matter there re 2^9 cycles. If one does not fix one cycle one obtains 2560 cycles - not Hamiltonian paths as I had erratically concluded. The cycles were actually listed (`http://tinyurl.com/yacgzm9x`) and classified to five different basic classes according to their symmetries. Even better, examples of cycles with symmetries were illustrated.

Cycles can be divided to isomorphy classes within which cycles have same shape.

1. It is possible to perform a shift of the edges along the cycle. The shape of the cycle is not affected but cycle changes. Using music terms the key changes. There are 12 different keys.

2. Also the mirror image mapping i^{th} edge to $(13-i)^{th}$ edge is a symmetry which in the generic case produces a new cycle. This symmetry should be distinguished from the change of the internal orientation which does not affect the cycle.

3. Also the isometries of icosahedron leaving the fixed edge as such act as symmetries. Fixed edge belongs to a triangle and the reflection mapping the two other edges of the triangle to each other is this kind of symmetry. Therefore there are two reflection symmetries and the number of cycles of same shape in the generic case is expected to be $4 \times 12 = 48$. If some of the symmetries acts trivially or if some isometries of icosahedron act as its symmetries, the number of isomorphic cycles is reduced.

It is even possible to find illustrations of the symmetric cycles (`http://tinyurl.com/y8ek7ak8`) obtained using Brendan McKay's NAUTY software (`http://tinyurl.com/dkftsr`)! From these illustrations (see **Figs. ??, ??** and **??**) one can by visual inspection deduce the numbers (n_0, n_1, n_2) charactering the cycle for classes involving symmetries. Also the basic chords can be deduced. If one trusts the condition $n_1 + 2 \times n_2 = 24$, it is enough to count the number n_2 triangles containing to path edges. I have also directly checked that n_1 comes out correctly.
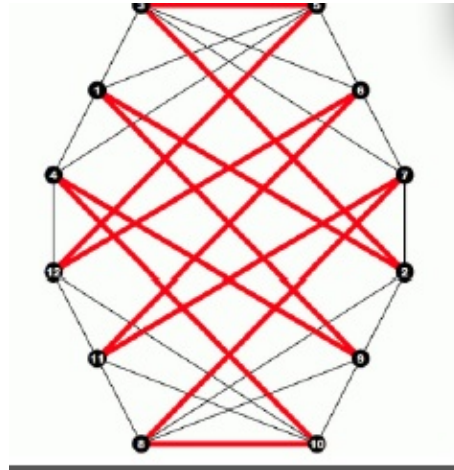
Figure 2.1: $((n_0, n_1, n_2) = (4, 8, 8)$ Hamiltonian cycle with 2 reflection symmetries acting in vertical and horizontal directions.

There are following isomorphic collections.

1. 6 asymmetric collections containing the maximal number of 48 cycles each. In this case images are not given.

2. 3 collections with 2-fold rotation symmetry containing 48/2=24 cycles each. One has $(n_0, n_1, n_2) \in \{(0, 16, 4), (0, 16, 4), (4, 8, 8)\}$.

3. 5 collections with reflectional symmetry containing 48/2=24 cycles each. One has $(n_0, n_1, n_2) \in \{(2, 12, 6), (2, 12, 6), (4, 8, 8), (2, 12, 6), (2, 12, 6)\}$.

4. 2 collections with 2 reflectional symmetries containing 48/4=12 cycles each. One has $(n_0, n_1, n_2) \in \{(0, 16, 4), (4, 8, 8)\}$.

5. 1 collection with 6-fold rotational symmetry containing 48/6= 8 cycles. One has $(n_0, n_1, n_2) = (2, 12, 6)$.
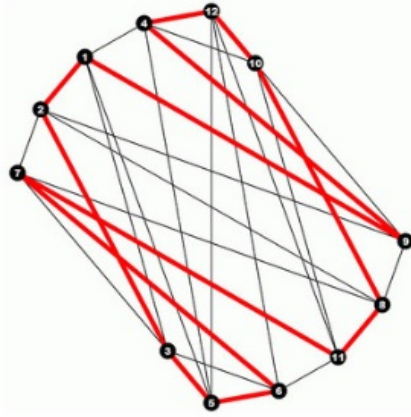
Figure 2.2: $((n_0, n_1, n_2) = (4, 8, 8)$ Hamiltonian cycle with 2-fold rotational symmetry acting as 6-quint rotation.

There are therefore 5 different notions of harmony and they correspond to $n = \{6, 3, 5, 2, 1\}$ sub-harmonies. This gives altogether 6+3+5+2+1= 17 different notions of harmony.

What is remarkable that the original candidate $(3, 10, 7)$ for bio-harmony is not realized as a cycle possessing symmetries (it might be realized as one of the asymmetric cycles) but that there are at least three realizations for $(4, 8, 8)$, which is forced by the condition that bio-harmony corresponds to the extended genetic code! The three $(4, 8, 8)$ cycles are illustrated in **Figs. ??, ??** and **??**.

2.6.3 Other Ideas

The book of Merrick discusses also other ideas. The attempts to understand music in TGD framework relate to these ideas.

p-Adic length scale hypothesis and music

One of the key ideas is the reduction of the octave phenomenon to the p-adic length scale hypothesis predicting that octaves and half-octaves correspond to p-adic scalings allowed by the hypothesis $p \simeq 2^k$ for the preferred values of the p-adic primes, and yielding scaled variants of physical systems. This idea will not be discussed in the following: suffice it to say that Pythagorean scale coming as powers of $p = 3$ strongly suggests approximate 3-adicity.

EEG and music

First of the key ideas relates to the idea that genetic code relates to the music scale.

1. Music metaphor is key element of TGD inspired view about biology and neuroscience. In particular, TGD based view about dark matter leads to the proposal that bio-photons are ordinary photons resulting as transformations of dark photons with large Planck constant $h_{eff} = nh$ to ordinary photons. The further hypothesis is that the energy spectrum of bio-photons is universal and contains visible photons and UV photons, which defined transition energies of biomolecules. This hypothesis follows if the value of h_{eff} assignable to a magnetic flux tube characterizes ion and is proportional to its mass number. The notion of gravitational Planck constant identified as $\hbar_{gr} = GMm/v_0$, where v_0 is a velocity parameter assignable to the two-particle system can be identified in the case of elementary particles and ions with h_{eff} and predicts also the universality of bio-photon spectrum.

2. In this framework bio-photons would represent music as light inducing molecular transitions. Notes that is different energies of bio-photons would correspond to different magnetic field
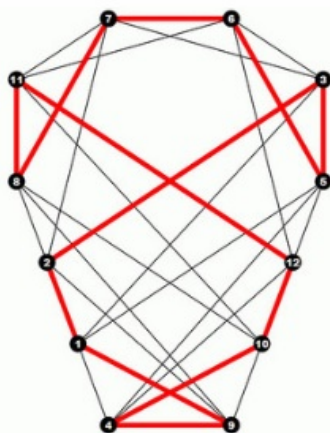
Figure 2.3: $((n_0, n_1, n_2) = (4, 8, 8)$ Hamiltonian cycle with 2-fold refection symmetry acting as horizontal reflection.

strengths at magnetic flux tubes as was proposed much earlier in the quantum model of hearing [K91]. Could the biochemical and physiological aspects involved with the generation of music experience be realized in terms of bio-photon emission induced by the listening of music?

Standing waves and music

Merrick consider the idea that standing waves are essential for music experience. Preferred extremals of Kähler action representing standing waves does not seem to be feasible. The known preferred extremals (with "massless extremals" (MEs) included) would represent superpositions of Fourier components with four-wave-vectors which are proportional to each other. Essentially pulse propagating in fixed direction. For more general extremals this direction can depend on position.

Although standing waves are not feasible, effects which would be explained in Maxwell's theory in terms of standing waves are possible in many-sheeted space-time. A particle in a region of Minkowski space containing several space-time sheets touches all space-time sheets having non-vanishing Minkowski space projection to this region and the forced experience by it is sum of the forces caused by them. This leads to an operational defines of gravitational and gauge fields of Einstein-Maxwell limit of TGD as sum of the deviations of the induced metric from Minkowski metric and sum of the components of the induced spinor connection defining classical gauge potentials in TGD framework.

Test particles can clearly experience the presence of standing waves. It is enough to take two massless extremals with opposite directions of three momentum but same energy with non-empty projections to same M^4 region. Particle with experience standing wave oscillating with the frequency involved. The arrangements in which photons are taken to rest effectively could correspond to this kind of situations since if it is the motion of test particles which serves as a signature. Note however that there are also vacuum extremals for which the light velocity at the space-time surface corresponds to arbitrarily low velocity at the level of embedding space.

Emotions and 4-D character of music experience

Music experience involves in an essential manner time unlike visual experience which is essentially 3-dimensional. Music experience affects also emotions very directly. For instance, we somehow know the key of the piece and expect that it ends to the basic note and chord. We somehow know also the scale used (say major or minor) by the emotional response stimulated by it. All this requires information about entire time evolution of the music piece. The recent neuroscience based models of memory do not help much in attempts to understand how this is possible. The

reason is that in the ordinary materialistic view in which the state of the brain at fixed time should determine the contents of consciousness.

The general vision in Zero Energy Ontology and Quantum Classical Correspondence is that space-time surface provide classical physics correlates for quantum states and also quantum jumps: the failure of the strict determinism is essential for the latter. The space-time surfaces are restricted inside causal diamond (CD) and have space-like 3-surface as their ends: the interpretation is as counterparts for the initial and final states of physical events.

The replacement of states with events makes it possible to understand mysterious looking facts about living matter such as standardized temporal patterns - say those appearing during morphogenesis. The maxima of the vacuum function defined by the exponent of Kähler function in term identified as Kähler action for Euclidian space-time regions representing analogs for the lines of Feynman graph correspond to the most probably temporal patterns.

The basic aspect of emotions is positive/negative dichotomy. An attractive identification for the physical correlated of this aspect is whether the quantum jump generating the emotion increases or decreases the negentropy of the subsystem involved. For instance, pain would correspond to a reduction of the negentropy for the body part involved. In music experience negentropy could flow between different parts of the system involved and create also sensation with local negative coloring but with overall positive coloring (by NMP [K70]). The ability of temporal patterns of music to generate negentropy flows inside the system involved could explain its effectiveness in generating emotions.

Dissonances were used by composes like Bach to generate melancholic emotions which suggests that the dissonance represent local reduction of negentropy. Also vibrato has emotional content. Physically dissonance and vibrato are assignable to the interference of frequencies which are near to each other (`http://tinyurl.com/5r34ch`). The basic formula is

$$cos(x) + cos(y) = cos((x + y)/2) \times cos((x - y)/2) \ .$$

Acknowledgements: I want to thank Tommi Ullgren for directing my attention to the book of Richard Merrick as well as for fascinating discussions about music.

2.7 Water And Life

2.7.1 Latest View About Water Memory

The notion of water memory has several aspects. Water memory was introduced by Benveniste [I48, I49] to explain the claimed ability of homeopathically treated water to behave as if it contained the original molecules. Already Benveniste discovered the connection with very low frequency electromagnetic radiation and claimed that the patterns of this radiation carry the information about the molecule and represent its biologically relevant aspects. Water memory has been also assigned to the observation suggesting that the human intent has effect on the crystal structures formed as water near criticality freezes [I109, I30].

Basic aspects of water memory

The first aspect of water memory relates to homeopathy and is discussed from strongly skeptic point of view in Wikipedia article (see `http://tinyurl.com/obvevp`. Mae Wan-Ho (see `http://tinyurl.com/29am8hz`) takes a more balanced view on homeopathy in her article discussing the recent findings of the research group of HIV Nobelist Luc Montagnier providing strong support for water memory and suggesting also a connection with gene level [I65, I66].

The basic principle of homeopathy is "let like be cured by like". Homeopathic remedies are highly diluted preparations believed to cause in the healthy individuals effects similar to the undesired symptoms of the person treated. Homeopathy is not in accordance with the naïve materialistic beliefs about what water is (just the letters H_2O!) and what happens in succussion process producing the remedy. Not surprisingly, hard-nosed skeptics are not able to discuss the subject without bursts of rage. Obviously, the claimed effect of homeopathic remedy resembles that of vaccine and one might say that the harmful substance serves as its own antibody (see `http://tinyurl.com/7obde`) eliminating the effect of the harmful substance. If one takes homeopathy

seriously, the challenge is to explain this auto-antibody behavior. One can of course ask whether this behavior could in some sense be the basic mechanism of immune system.

In Benveniste's experiments [I48, I49] antibodies of human basophils were dissolved in water and the claim of experiments was that basophils added to the homeopathically treated water produced allergic reaction serving usually as a signature for the presence of antibody. As if water were able to mimic the antibodies in biologically relevant aspects. Later Benveniste was labeled as a fraud but the research has continued and it has been for long time thought that low frequency electromagnetic fields are essential for water memory. The frequencies in question extend to kHz range and cannot relate to molecular transitions. Cyclotron frequencies assignable to charged particles at the magnetic body of the molecule are the natural candidate in TGD framework.

Second aspect of water memory relates to the claim that human intent has an effect on the molecular structure of water. Clearly a special variant of remote mental interaction would be in question. Masaru Emoto [I109] has photographed water crystals resulting from water contained by a glass and subject to human intent. Depending on the origin of water the resulting water crystals can vary from random to very organized and aesthetic. Words, pictures, and music are used to generate the crystals. It is important to not forget that human intent is a decisive factor so that water need not be able to read as one especially simplistic and aggressive fanatic ridiculing Emoto claimed! Emoto has published several books containing pictures of the crystals and makes explicit that he is not a scientist but photographer who has discovered a fascinating new phenomenon and loves to document it.

Mae Wan-Ho has written an article titled "Crystal Clear - Messages from Water" (see `http://tinyurl.com/yjj9t4k`) [I109] in which she discusses Emoto's work with intellectual honesty and giving primacy for facts instead of dogmas. The basic argument of skeptic is that water is just H_2O as we learned in school and therefore Emoto must be a swindler. The Wikipedia article (see `http://tinyurl.com/dh4g6s`) [I18] about Masaru Emoto's work represents a rather civilized skeptic reaction as compared to Harriet Hall's (see `http://tinyurl.com/ot8zunw`) piece of bad rhetorics filled with nasty ad hominem attacks. More ambitious skeptic believer bothers to develop an argument claiming that aesthetic appeal is highly subjective measure to characterize the water crystals. Here common sense and intellectual honesty clash with materialistic dogmas categorically denying this kind of effects, and the reader of these books must make a personal decision about what might be the truth - unless they decide to become photographers of water crystals.

The reader can also form his or her opinion about this aspect of water memory by looking the You tube video "Water has Memory" (see `http://tinyurl.com/d7oto3d`) [I30] prepared in Aerospace Institute in Stuttgart illustrating that the effect of human intent on the structure of water droplets is same for droplets from same source, is repeatable, and characterizes the operator. Also the effect of flowers dropped into the water is illustrated. All drops from a given source give rise to same structure characterizing the flower. It is suggested that water is a huge information source and serves as a kind of data medium. This proposal is highly trivial and would mean a profound modification of world view.

A simple model for water memory

Suppose that we just for a moment decide to overcome our intellectual laziness and are not satisfied with the standard rhetoric tricks of skeptics to convince ourselves that water memory researches must be swindlers or fools. In other words, we take the experimental evidence supporting water memory as something worth of considering seriously and try to build a model for the claimed phenomena. We can indeed imagine when we do not know. The challenge of the model for water memory is to explain the claimed basic aspects of water memory with minimal assumptions. Let us the restrict the model building further by assuming that we live in TGD Universe and that our vision about this Universe is roughly correct.

The ability of water molecule clusters to mimic the possibly harmful substances - call them just H - dissolved in water in some biologically relevant aspects could explain the effectiveness of homeopathic remedies. Water should make possible a symbolic representation of the molecules or their magnetic bodies.

1. Suppose H is a polar molecule so that it is biologically effective and that magnetic body characterizes the relevant biological effects of a polar molecule. Suppose that mechanical

agitation causes some polar molecules to lose their magnetic bodies so that they attach to water molecule clusters, which therefore become "actors" representing H. In the dilution the density of the fake molecules is also reduced but if the energy provided by shaking can be used as metabolic energy makes possible for the "actors" to replicate and their population can survive and even evolve in the sequence of "environmental catastrophes" induced by repeated succussions possibly also inducing evolution as an increase of Planck constant for the magnetic body of the "actor". Also the replication of the magnetic body of the "actor" is required. Cyclotron frequency spectrum would serve as a characterizer of molecule's magnetic body and cyclotron radiation would make possible communications between fake molecules and their magnetic body.

2. What the dropping of magnetic bodies really means? To answer the question consider a general vision about what happens as energy is fed into a system consisting of proteins dissolved in water. The proteins originally in closed globular configuration open as the ordered water covering their surfaces with "ice" melts. This leads to a protein aggregation (see `http://tinyurl.com/yarrblxn`) during the short "molecular summer" provided by the energy feed. The outcome is braiding and reconnection of flux tubes.

   Suppose that this mechanism is at work also when proteins are replaced with harmful polar molecules. During "molecular summer" a reconnection process for closed loops emerging from water clusters and polar molecules would connect them with water clusters. Also the magnetic bodies of polar molecules would generate connections to water clusters via molecules. Self-reconnection for the flux tubes going through H molecules makes possible the transfer of the magnetic body of H to water molecule cluster. Water molecule cluster would "steal" the magnetic coat of H and H molecules would be left with short-cut closed flux tubes after the reconnection.

3. What is required that these water clusters or something associated with them can replicate and develop to a population representing the original molecules. The needed metabolic energy would come from mechanical agitation. Note that this replication should involve also the replication of magnetic bodies which suggests that linear structures generating planar flux tubes emanating from the basic building bricks of the structure are involved. This will be discussed below.

What could then be the healing mechanism in homeopathy? Why the presence of the fake molecules in organism would prevent the harmful actions of real molecules in the organism? What could be the translation of "Let like be cured by like" to the language of quantum TGD?

1. Suppose that the effects of H on bio-molecules are due to cyclotron radiation along the flux tubes of its magnetic body connecting it to bio-molecules of the organism. Suppose that the fake representatives of H contained by the homeopathic remedy and real molecules H reconnect so that the flux loops associated with H and fake H reconnect to a pair of flux tubes connecting H and fake H. Suppose that this happens with such high a rate that the fraction of the connections to other biomolecules remains low.

2. If so, fake H would effectively act antibody of H and the effects of H via its magnetic body on organism would be minimized. Like would indeed cure like. Could this reconnection mechanism be at work also when antibody attaches to the harmful molecule? If so, the basic mechanism of immunization would be universal and involved the notion of magnetic manner in an essential manner.

Dark nucleon genetic code as realization of water memory, and homeopathic mechanism as basic mechanism of immune system

The proposal says nothing about the detailed structure of water clusters, and does not mention dark nucleons nor the proposal for the realization of genetic code based on them. A more refined model would include also these and give a connection for how immune system would utilize the reconnection of flux tubes defining the basic mechanism of homeopathy.

1. TGD predicts a realization of vertebrate genetic code at the level of dark nucleons. Dark nucleons correspond to the states of DNA, RNA, tRNA, and amino-acids and represent vertebrate genetic code under rather general assumptions [L3]. One could even consider the extension of the genetic code to a naming of polar molecules by sequences of representatives of DNA letters. Suppose that dark proton sequences are attached to a polar molecule dissolved in water, and define a representation of the molecule in terms of code letters realized as exotic protons with Compton length in nano-scale. The assignment of the magnetic body of the molecule to water cluster would give it the same "name" as for the original molecule. It is of course possible to have other representation and one of them would be in terms of dark u quarks providing representation of A, T, C, G in terms of spin states.

2. If the population of dark DNA molecules assigned with the harmful substance H is able to use the energy provided by the succussion process as a metabolic energy for replication, the disappearance of H is compensated by the replication of dark DNA representing it. Dark DNA becomes the representative of H. The growing population would consist of dark DNA and the flux tubes of the magnetic body connect to dark DNA strands. Replication would be the analog of that for ordinary DNA and involve also the replication of magnetic bodies. The water would contain pairs of dark DNA and its conjugate connected by a flux tube and these flux tubes would reconnect with flux tubes connecting the dark DNA sequence representing H and connected by flux tubes to its conjugate.

3. It is known that the DNA of the immune system evolves with an especially high rate. Could the universal naming mechanism allow the immune system to generate new immune responses via the transcription of the dark DNA sequence representing the harmful molecule to a real DNA, which in turn codes for amino-acid attaching to the harmful molecules along the dark nucleon sequence? A model for homeopathy would extend to a model for the functioning of immune system. This would be of course also a mechanism of evolution as a reaction to changing chemical environment. This would explain also the effect of the homeopathic remedy as an effect at gene level.

   It is difficult to exaggerate the potential significance of this mechanism for biology, genetic engineering, and medicine. Understanding of the contemptible homeopathy could induce decisive step in the understanding of biology. This possibility shows how dangerous it is to take the claims forced by a particular belief system like materialism as final truths.

Reader has certainly noticed that reconnection mechanism pops up again and again in the model and would be also the fundamental mechanism of ordinary DNA replication, transcription, translation of mRNA to proteins, and of process catching tRNA molecules carrying amino-acids to form protein at mRNA. This mechanism would be realized even in the mutual interactions between living organisms and between living organisms and inanimate matter.

Braiding represents as a higher level aspect of water memory

Braiding represents another aspect of water memory relating to the representation as dark nucleon sequences as the quantum computer programs represented by braidings to DNA in the model of DNA as topological quantum computer [K5]. The memories represented by braiding would be about the flow of water and molecules rather than about substances present in the water. The model of qualia [K50] is based on flux tube connections between system representing self and environment. For polar molecules the qualia would relate to charge and electric polarization. Could the qualia assignable to polar molecule plus environment have scaled down fractal variants at the level of water clusters of environment? If this were the case then water would effectively produce representations about molecule at the level of qualia. Could also these relate to water memory?

Effects of intent on water crystallization

One should understand the effect of intent on water in terms of water memory. The proposed representation of polar molecules in terms of dark DNA sequences is one possible realization of water memory reducing naming of molecules to genetic code letters. Essentially addressing of

molecules would be in question. This aspect of water memory is not relevant now. Rather, what matters is the interaction of water with human operator and reconnection of flux tubes of magnetic bodies is a good guess for how this interaction is realized. The same mechanism is involved also with the interaction of homeopathic remedy and harmful substance.

How could one understand the effect of intent on water crystallization, which characterizes the operator involved. The situation would be very much like that in the experiments of Tiller [J123]. The magnetic bodies assignable to the operator and water must interact and produce the effects. This would not be surprising if similar interaction takes place in the case of dissolved substances.

A concrete model for the interaction would be in terms of the reconnections of closed flux tubes emerging from the biological body of subject person with the flux tubes of the magnetic body of water creating direct flux tube contacts between the two bodies. The presence of magnetic flux tube connections between water sample and operator's magnetic and biological body would induce the effects on crystallization of water. Water memory should be stable in human time scales. This requires that these flux tube patterns are rather stable modification of the magnetic body of water. Large values of Planck constant assignable to the magnetic body of human agent would be needed. What is required is that the crystallization patterns and therefore structures of water clusters correlate with the structure of the magnetic body of the water sample.

Magnetic body and migrating birds

What happens when the water glass in the experiments of Emoto is taken to a large distance from operator? Does the effect prevail? If the magnetic flux tubes stretch, this interaction need not cease as the distance between operator and water glass increases unless the double flux tube splits by self-reconnection. If so, water could indeed act as a data medium as proposed in the video about water memory.

Magnetic body could play key role in understanding how birds and fish manage to find their birth places during migration is one of the many unresolved mysteries of biology. It has been suggested that orienteering in magnetic field of Earth using neuron level compass is in question but this proposal has its difficulties. Could it be that the birds and fish are connected by the magnetic flux tubes of their personal magnetic body or of that of the species to the birth place so that they would only follow Ariadne's thread?

2.7.2   Genes And Water Memory

After long time I had opportunity to read a beautiful experimental article about experimental biology. Yolene Thomas, who worked with Benveniste, kindly sent the article to me. The freely loadable article is *Electromagnetic Signals Are Produced by Aqueous Nanostructures Derived from Bacterial DNA Sequences* by Luc Montagnier, Jamal Aissa, Stephane Ferris, Jean-Luc Montagnier, and Claude Lavall'e published in the journal Interdiscip. Sci. Comput. Life Sci. (2009) [I65].

Basic findings at cell level

I try to list the essential points of the article. Apologies for biologists: I am not a specialist.

1. Certain pathogenic micro-organisms are objects of the study. The bacteria Mycoplasma Pirum and E. Choli belong to the targets of the study. The motivating observation was that some procedures aimed at sterilizing biological fluids can yield under some conditions the infectious micro-organism which was present before the filtration and absent immediately after it. For instance, one filtrates a culture of human lymphocytes infected by M. Pirum, which has infected human lymphocytes to make it sterile. The filters used have 100 nm and 20 nm porosities. M. Pirum has size of 300 nm so that apparently sterile fluids results. However if this fluid is incubated with a mycoplasma negative culture of human lymphocytes, mycoplasma re-appears within 2 or 3 weeks! This sounds mysterious. Same happens as 20 nm filtration is applied to a a minor infective fraction of HIV, whose viral particles have size in the range 100-120 nm.

2. These findings motivated a study of the filtrates and it was discovered that they have a capacity to produce low frequency electromagnetic waves with frequencies in good approximation coming as the first three harmonics of kHz frequency, which by the way plays also a central role in neural synchrony. What sounds mysterious is that the effect appeared after appropriate dilutions with water: positive dilution fraction varied between 10^{-7} and 10^{-12}. The uninfected eukaryotic cells used as controls did not show the emission. These signals appeared for both M. Pirum and E. Choli but for M. Pirum a filtration using 20 nm filter canceled the effect. Hence it seems that the nano-structures in question have size between 20 and 100 nm in this case.

A resonance phenomenon depending on excitation by the electromagnetic waves is suggested as an underlying mechanism. Stochastic resonance familiar to physicists suggests itself and also I have discussed it while developing ideas about quantum brain [K95]. The proposed explanation for the necessity of the dilution could be kind of self-inhibition. Maybe a gel like phase which does not emit radiation is present in sufficiently low dilution but is destroyed in high dilutions after which emission begins. Note that the gel phase would not be present in healthy tissue. Also a destructive interference of radiation emitted by several sources can be imagined.

3. Also a cross talk between dilutions was discovered. The experiment involved two tubes. Donor tube was at a low dilution of E. Choli and "silent" (and carrying gel like phase if the above conjecture is right). Receiver tube was in high dilution (dilution fraction 10^{-9}) and "loud". Both tubes were placed in mu-metal box for 24 hours at room temperature. Both tubes were silent after his. After a further dilution made for the receiver tube it became loud again. This could be understood in terms of the formation of gel like phase in which the radiation does not take place. The effect disappeared when one interposed a sheath of mu-metal between the tubes. Emission of similar signals was observed for many other bacterial specials, all pathogenic. The transfer occurred only between identical bacterial species which suggests that the signals and possibly also frequencies are characteristic for the species and possibly code for DNA sequences characterizing the species.

4. A further surprising finding was that the signal appeared in dilution which was always the same irrespective of what was the original dilution.

Experimentation at gene level

The next step in experimentation was performed at gene level.

1. The killing of bacteria did not cancel the emission in appropriate dilutions unless the genetic material was destroyed. It turned out that the genetic material extracted from the bacteria filtered and diluted with water produced also an emission for sufficiently high dilutions.

2. The filtration step was essential for the emission also now. The filtration for 100 nm did not retain DNA which was indeed present in the filtrate. That effect occurred suggests that filtration destroyed a gel like structure inhibiting the effect. When 20 nm filtration was used the effect disappeared which suggests that the size of the structure was in the range 20-100 nm.

3. After the treatment by DNAse enzyme inducing splitting of DNA to pieces the emission was absent. The treatment of DNA solution by restriction enzyme acting on many sites of DNA did not suppress the emission suggesting that the emission is linked with rather short sequences or with rare sequences.

4. The fact that pathogenic bacteria produce the emission but not "good" bacteria suggests that effect is caused by some specific gene. It was found that single gene - adhesin responsible for the adhesion of mycoplasma to human cells- was responsible for the effect. When the cloned gene was attached to two plasmids and the E. Choli DNA was transformed with the either plasmid, the emission was produced.

Some consequences

The findings could have rather interesting consequences.

1. The refinement of the analysis could make possible diagnostics of various diseases and suggests bacterial origin of diseases like Alzheimer disease, Parkinson disease, Multiple Sclerosis and Rheumatoid Arthritis since the emission signal could serve as a signature of the gene causing the disease. The signal can be detected also from RNA viruses such as HIV, influenza virus A, and Hepatitis C virus.

2. Emission could also play key role in the mechanism of adhesion to human cells making possible the infection perhaps acting as a kind of password.

The results are rather impressive. Some strongly conditioned skeptic might have already stopped reading after encountering the word "dilution" and associating it with a word which no skeptic scientist in his right mind should not say aloud: "homeopathy" ! By reading carefully what I wrote above, it is easy to discover that the experimenters unashamedly manufactured a homeopathic remedy out of the filtrate! And the motivating finding was that although filtrate should not have contained the bacteria, they (according to authors), or at least the effects caused by them, appeared within weeks to it! This is of course impossible in the word of skeptic.

The next reaction of the skeptic is of course that this is fraud or the experimenters are miserable crackpots. Amusingly, one of the miserable crackpots is Nobelist Luc Montagnier, whose research group discovered AIDS virus.

How TGD could explain the findings?

Let us leave the raging skeptics for a moment and sketch possible explanations in TGD framework.

1. Skeptic would argue that the filtration allowed a small portion of infected cells to leak through the filter. Many-sheeted space-time suggests a science fictive variant of this explanation. During filtration part of the infected cells is "dropped" to large space-time sheets and diffused back to the original space-time sheets during the next week. This would explain why the micro-organisms were regenerated within few weeks. Same mechanism could work for ordinary molecules and explain homeopathy. This can be tested: look whether the molecules return back to the diluted solution in the case of a homeopathic remedy.

2. If no cells remain in the filtrate, something really miraculous looking events are required to make possible the regeneration of the effects serving as the presence of cells. This even in the case that DNA fragments remain in the filtrate.

   (a) The minimum option is that the presence of these structures contained only the relevant information about the infecting bacteria and this information coded in terms of frequencies was enough to induce the signatures of the infection as a kind of molecular conditioning. Experimentalists can probably immediately answer whether this can be the case.

   (b) The most radical option is that the infecting bacteria were actually regenerated as experimenters claim! The information about their DNA was in some form present and was transcribed to DNA and/or RNA, which in turn transformed to proteins. Maybe the small fragment of DNA (adhesin) and this information should have been enough to regenerate the DNA of the bacterium and bacterium itself. A test for this hypothesis is whether the mere nanoparticles left from the DNA preparation to the filtrate can induce the regeneration of infecting molecules.

The notion of magnetic body carrying dark matter quantum controlling living matter forms the basic element of TGD inspired model of quantum biology and suggests a more concrete model. The discovery of nanotubes connecting cells with distance up to 300 μ [I40] provides experimental support for the notion.

1. If the matter at given layer of the onion-like structure formed by magnetic bodies has large $\hbar$, one can argue that the layer corresponds to a higher evolutionary level than ordinary matter with longer time scale of memory and planned action. Hence it would not be surprising if the magnetic bodies were able to replicate and use ordinary molecules as kind of sensory receptors and motor organs. Perhaps the replication of magnetic bodies preceded the replication at DNA level and genetic code is realized already at this more fundamental level somehow. Perhaps the replication of magnetic bodies induces the replication of DNA as I have suggested.

2. The magnetic body of DNA could make DNA a topological quantum computer [K5]. DNA itself would represent the hardware and magnetic bodies would carry the evolving quantum computer programs realized in terms of braidings of magnetic flux tubes. The natural communication and control tool would be cyclotron radiation besides Josephson radiation associated with cell membranes acting as Josephson junctions. Cyclotron frequencies are indeed the only natural frequencies that one can assign to molecules in kHz range. There would be an entire fractal hierarchy of analogs of EEG making possible the communication with and control by magnetic bodies.

3. The values of Planck constant would define a hierarchy of magnetic bodies which corresponds to evolutionary hierarchy and the emergence of a new level would mean jump in evolution. Gel like phases could serve as a correlate for the presence of the magnetic body. The phase transitions changing the value of Planck constant and scale up or down the size of the magnetic flux tubes. They are proposed to serve as a basic control mechanism making possible to understand the properties and the dynamics of the gel phases and how biomolecules can find each other in the thick molecular soup via a phase transition reducing the length of flux tubes connecting the biomolecules in question and thus forcing them to the vicinity of each other.

   Consider now how this model could explain the findings.

1. Minimal option is that the flux tubes correspond to "larger space-time sheets" and the infected cells managed to flow into the filtrate along magnetic flux tubes from the filter. This kind of transfer of DNA might be made possible by the recently discovered nanotubes already mentioned.

2. Maybe the radiation resulted as dark photons invisible for ordinary instruments transformed to ordinary photons as the gel phase assignable with the dark matter at magnetic flux tube network associated with the infected cells and corresponding DNA was destroyed in the filtration.

   This is not the only possible guess. A phase conjugate cyclotron radiation with a large value of Planck constant could also allow for the nanostructures in dilute solute to gain metabolic energy by sending negative energy quanta to a system able to receive them. Indeed the presence of ambient radiation was necessary for the emission. Maybe that for sufficiently dilute solute this mechanism allows to the nanostructures to get metabolic energy from the ambient radiation whereas for the gel phase the metabolic needs are not so demanding. In the similar manner bacteria form colonies when metabolically deprived. This sucking of energy might be also part of the mechanism of disease.

3. What could be the magnetic field inducing the kHz radiation as a synchrotron radiation?

   (a) For instance, kHz frequency and its harmonics could correspond to the cyclotron frequencies of proton in magnetic field which field strength slightly above that for Earth's magnetic field (750 Hz frequency corresponds to field strength of B_E, where $B_E = .5$ Gauss, the nominal strength of Earth's magnetic field). A possible problem is that the thickness of the flux tubes would be about cell size for Earth's magnetic field from flux quantization and even larger for dark matter with a large value of Planck constant. Of course, the flux tubes could make themselves thinner temporarily and leak through the pores.

(b) If the flux tube is assumed to have thickness of order 20-100 nm, the magnetic field for ordinary value of $\hbar$ would be of order.1 Tesla from flux quantization and in the case of DNA the cyclotron frequencies would not depend much on the length of DNA fragment since the it carries a constant charge density. Magnetic field of order.2 Tesla would give cyclotron frequency of order kHZ from the fact that the field strength of.2 Gauss gives frequency of about .1 Hz. This correspond to a magnetic field with flux tube thickness ~ 125 nm, which happens to be the upper limit for the porosity. Dark magnetic flux tubes with large $\hbar$ are however thicker and the leakage might involve a temporary phase transition to a phase with ordinary value of $\hbar$ reducing the thickness of the flux tube. Perhaps some genes (adhesin) plus corresponding magnetic bodies representing DNA in terms of cyclotron frequencies depending slightly on precise weight of the DNA sequence and thus coding it correspond to the frequency of cyclotron radiation are the sought for nano-structures.

4. While developing a model for homeopathy based on dark matter I ended up with the idea that dark matter consisting of nuclear strings of neutrons and protons with a large value of $\hbar$ and having thus a zoomed up size of nucleon could be involved. The really amazing finding was that nucleons as three quark systems allow to realize vertebrate code in terms of states formed from entangled quarks [L3], [L3] described also in this chapter! One cannot decompose codons to letters as in the case of the ordinary genetic code but codons are analogous to symbols representing entire words in Chinese. The counterparts of DNA, RNA, and amino-acids emerge and genetic code has a concrete meaning as a map between quantum states.

   Without any exaggeration this connection between dark hadronic physics and biology has been one of the greatest surprises of my professional life. It suggests that dark matter in macroscopic quantum phase realizes genetic code at the level of nuclear physics and biology only provides one particular (or probably very many as I have proposed) representations of it. If one takes this seriously one can imagine that genetic information is represented by these dark nuclear strings of nanoscopic size and that there exists a mechanism translating the dark nuclei to ordinary DNA and RNA sequences and thus to biological matter. This would explain the claimed regeneration of the infected cells.

5. Genetic code at dark matter level would have far reaching implications. For instance, living matter - or rather, the magnetic bodies controlling it - could purposefully perform genetic engineering. This forces me to spit out another really dirty word, "Lamarckism" ! We have of course learned that mutations are random. The basic objection against Lamarckism is that there is no known mechanism which would transfer the mutations to germ cells. In the homeopathic Universe of TGD the mutations could be however performed first for the dark nucleon sequences. After this these sequences would diffuse to germ cells just like homeopathic remedies do, and after this are translated to DNA or RNA and attach to DNA.

The findings of both Montagnier and Gariaev suggests that also the representation of genetic code in terms of dark photons is involved. How genetic code could be represented in terms of frequencies? The TGD based model of music harmony [L19] [K91] (see `http://tinyurl.com/zg3aaj7`) relies on the idea that 12-note scale is representable as a closed non-self-intersecting curve (Hamilton's cycle) at icosahedron having 12 vertices. The harmony assignable to a given Hamilton's cycle is characterized in terms of 3-chords assignable to the 20 faces (triangles) of the icosahedron once the 12-note scale is represented as a particular Hamilton's cycle.

Remarkably, the number of amino-acids is also 20! One indeed ends up with a model in which 20+20+20=60 DNA codons are represented by 3-chords for a triplet of harmonies defined by Hamilton's cycles predicting correctly the numbers of DNAs coding for a given amino-acid for vertebrate code. One must however assume that also tetrahedral harmony is present to get 64 DNA codons rather than only 60. TActually two variants of the code are predicted and altogether one obtains the standard 20 amino-acids plus two additional ones identified as Pyl and Sec known to be realized in living matter.

In music realization DNA codons can be represented as 3 dark photons or phonons with appropriate frequency ratios. This representation could explain the findings of Montagnier and

Gariaev. There is also a connection with TGD inspired theory of consciousness. Music both expresses and induces emotions. The proposal is that the representation of DNA codons in terms of triplets of sounds or dark photons defines molecular level representation of emotions. There is large number of different harmonies and they could represent different moods.

2.7.3   Water Electric As Protocell

Ulla Matfolk sent to me some interesting material at the web page of Dr. Mae-Wan Ho which provides further insights into the model of cell. The articles are "Water electric" [D64] and "Making Fuel from Water" [D62]. The articles summarize an experimental discovery which could be called Pollack-Zheng effect [D72, D66]. Both articles relate closely to what might be called the holy grail of artificial photosynthesis. The unreasonable effectiveness of photosynthesis in the sense that the waste of energy during the process is extremely small, makes artificial photosynthesis an excellent candidate for the final solution of energy problems as far energy sources and minimization of wastes are considered. In the following I comment only the first paper in detail from TGD viewpoint.

How photosynthesis manages to be so effective is one of the mysteries of biology. TGD based view about metabolic energy involves two ideas.

1. TGD predicts a hierarchy of metabolic energy quanta [K17, K57]. The basic quanta come as $E(k) = 2^k E_0$, where k is positive or negative integer and $E_0 \simeq .5$ eV holds true. For instance, 2 eV metabolic energy quantum corresponding to red light corresponds to $k = 3$. This is actually oversimplification since there is a cascade of quanta $E(k, n) = (1 - 2 < sup > -n < /sup >)E(k)$ converging to $E(k)$ for each p-adic length scale. These energies correspond to energies liberated when electron or proton drops to a larger space-time sheet at the limit when second space-time becomes very large and the particle starts from rest and remains to rest: this is second idealization as also the particle in a box geometry. The idea is that these universal metabolic energy quanta preceded the metabolism based on chemical storage of energy and that the primary step in photosynthesis is kicking of proton or electron to a smaller space-time sheet.

2. Second idea relies on the hierarchy of Planck constants.

   (a) The rate of dissipation - that this the energy wasted per unit time - is inversely proportional to $\hbar$ in the first naïve guess and means that macroscopically quantum coherent dark matter dissipates very little. Could photon kick charged dark particles to smaller space-time sheet where they dissipate very little? Or could photosynthesis capture ordinary or dark photons of sunlight to some layer of the onion like structure formed by the magnetic body of the organism, where it kicks particles to smaller space-time sheets. This light could correspond to bio-photons liberated as the biological body of the organism dies.

   (b) Could this storage of photons have preceded chemical storage of energy in living matter? And could this energy reserve explain some rather mysterious findings about the ability of some people to survive without ordinary metabolic energy feed (usually saints and this kind of people telling that light is enough for them to survive. Also animals are capable to these metabolic miracles [I43] : see the article "Researchers Seek to Demystify the Metabolic Magic of Sled Dogs" in Science. Of course, the storage of energy to that of dark matter or dark photons confined to the net defined by magnetic flux tubes could be the eventual manner to avoid energy waste and associated entropy growth inducing environmental problems. Hierarchy of Planck constants would allow the storage in arbitrary long length scales for given energy of photon so that even a community of organisms could have collective metabolic energy resources: maybe synergy has something to do with this.

The first article summarizing the Pollack-Zheng effect gives quantitative support for this picture. I have formatted the text as comments to the summary represented in the article of Mae-Wan Ho [D64].

Exclusion zones

The article summarizes the sequence of events initiated by the discovery of Gerald Pollack and his student Jian-ming Zheng [D72, D66]. As a matter fact, the fascinating findings described in detail by Gerald Pollack in his book were absolutely crucial for the recent TGD based view about quantum biology in which dark matter plays key role.

1. Pollack and his student discovered that suspensions of colloids and dissolved substances are excluded from a region extending some hundreds of micrometres from the surfaces of hydrophilic gels. An "exclusion zone" (EZ) of this magnitude conflicts the belief that interfacial water forming at liquid-solid, or liquid-air interfaces can be no more than a few layers of molecules thick. What's observed is a million layers or more! "Exclusion" means that the water suspension of micro-spheres moved away from the surface of gel with constant velocity and behaving like single structural unit.

   Comment: The sizes of cells vary up to hundreds of micrometers and cells are by definition structures which are isolated from the environment. Maybe EZs represent protocells or their precedessors. Pollack and coauthors have indeed proposed that their finding might relate to the origin of life [D66]. That the surface was that of gel might be important. In TGD based model of living matter gels have magnetic bodies and their presence might relate to the formation of the thick water layer in non-standard phase.

2. Similar exclusion zones were found next to any hydrophilic surface including surfaces coated with a monolayer of hydrophilic molecules, and around ion exchange resin beads. Electric charge appears to be important, as EZ failed to form around charge-exhausted resin beads. Although EZ can form in pure water, it is enhanced and stabilized by low concentrations of buffer (2 to 10 mM at pH 7).

   Comment: Hydrophily could correspond to the formation of magnetic flux tubes connecting the hydrophilic surface to water molecules as assumed in the model of protein folding and bio-catalysis [K10].

3. The EZ phase is very different from the bulk water. An unusually ordered crystalline phase where the molecules are less free to move is suggestive. The UV and visible absorption spectrum gave a single absorption peak at $\lambda \simeq 270$ nm in the UV region completely absent in the bulk phase. The infrared emission record showed that the EZ radiates very little compared with bulk water, as would be expected on account of the reduced mobility of water molecules. The magnetic resonance imaging mapping similarly gave a transverse relaxation time (T2) of 25.4 + 1 ms, which is shorter than the 27.1 + 0.4 ms recorded for the bulk water phase, again indicative of restricted motion.

   Comment: The reduced radiation might mean that part of photons are dark and bound inside magnetic flux tubes defining a structure responsible for the formation of gel like phases inside cell and perhaps also inside EZ. The interpretation as bio-photons is suggestive. This phase of water could be precedessor of the water in cell interior since in the crystalline phase long bio polymers like DNA and amino-acid sequences would be stable against hydration.

4. EZ had a different electrical potential from the bulk phase, by as much as 100 200 mV, depending on the hydrophilic surface. With a negatively charged surface such as polyacrylic acid or Nafion (widely used as a proton exchange membrane), the potential is negative compared with the bulk water away from the EZ. Simultaneously, the hydrogen ion (proton, H^+) concentration is high just outside the EZ, decreasing in a gradient away from it. This indicates that the formation of the EZ is accompanied by a separation of positive and negative electrical charges, which led to the build up of electrical potential between the EZ and the bulk water. In effect, the water has become an electrical battery, and can provide electricity through an external circuit.

   Comment: Cell membrane is also a battery and the potential is around 50-80 mV to be compared with 100 200 mV, and the size scale of cell varies from 5 micrometer to hundreds of micrometers so that EZs could be involved with the formation of cell and cell membranes. The kicking of electrons or protons to smaller space-time sheet could be the mechanism

inducing electric potential at a given space-time sheet. The formation of battery would mean that water could some day used to store very effectively the energy of solar radiation.

A connection with photosynthesis

Separating H^+ from e^- (electron) is the first step of photosynthesis in green plants which provides energy for most of the biosphere. In this case the energy comes from solar radiation. The separation of charges requires energy also in the case of EZ and the question is where this energy comes from in the case of EZ.

1. A clue came after having inadvertently left the experimental chamber with the EZ on the microscope overnight. Next morning, the EZ had shrunk considerably. But after turning on the microscope lamp, it began to immediately grow again, restoring itself within minutes to its former size. The energy for EZ formation comes from light, as in photosynthesis, but it can use the low energy part of the solar spectrum that photosynthesis cannot.

   Comment: Could one consider the possibility that photosynthesis involves unknown step and this step is just the kicking of electrons or protons to a smaller space-time sheet. This step would also induce the separation of charges and the generation of electric potential.

2. Although the entire spectrum of visible light appeared effective in making the EZ grow, the most effective part is in the infrared region, peaking at $\lambda \simeq 3100$ nm. A 10 minute exposure at that wavelength expanded the width of an EZ 3.7 times, and after an hour of exposure, the expansion was more than 6 times. After the light was turned off, the EZ remained constant for about 30 minutes before beginning to shrink, reaching halfway to its baseline level in about 15 minutes.

   Comment: $\lambda = 3100$ nm corresponds to .4 eV. The nominal value of the fundamental metabolic energy quantum is around $E_0 = .5$ eV and one has $E(k = 0, n = 3) = 0.4375$ eV for this value of E_0. Perhaps the photons indeed kick electrons or protons to a smaller space-time sheet.

   (a) In the case of protons the smaller space-time sheet would correspond to atomic space-time sheets characterized by $p \simeq 2^{137}$: the larger one would correspond to to $k = 141$.

   (b) For electrons the size of the smaller space-time sheet would be by a factor $m_p/m_e = 940/.5 = 1880 \simeq 2^{11}$ larger and would correspond to $k = 137 + 11 = 148$. This served as one motivation for the original $\hbar/\hbar_0 = 2^{11k}$ hypothesis for the preferred values of Planck constant. This is one half of the thickness of the lipid layer of cell membrane. The larger space-time sheet would correspond to cell membrane thickness $L(151) = 10$ nm and perhaps the dark space-time sheet serving as a template for the formation of the cell membrane! If $E = .4$ eV corresponds to electron, then proton would correspond to $E(0,3) = .44$ eV giving for the metabolic energy quantum the value $E_0(p) = 0.5029$ eV in the case of proton and $E_0(e) = 0.4616$ eV in the case of electron.

3. When the UV and visible range was tested, a peak in the degree of EZ expansion was detected at $\lambda = 270$ nm in the UV region, corresponding to the characteristic absorption peak of EZ that was identified before. However, as the optical power used in the UV and visible region was 600 times that in the IR, the most profound effect was identified in the IR region, particularly at 3 100 nm.

   Comment: $\lambda = 270$ nm corresponds to the energy 4.5926 eV. E=4 eV is the nearest metabolic energy quantum. This energy does not correspond directly to any metabolic energy quantum assignable to .4 eV or .43 eV. One must be however cautious with conclusions since the model is very rough.

4. The mechanism of EZ formation is still unknown. But the two wavelengths that expand the EZ most effectively may offer some hint. The UV wavelength 270 nm is close to the 250 nm ($\simeq 5$ eV) required to ionize water under standard state conditions and taking into account the hydration of the resulting ions. The 3 100 nm peak, on the other hand is close to the OH stretch of the ring hexamer identified as the most abundant species in infrared predissociation

spectroscopy of large water clusters, and also in neon matrices by infrared spectroscopy. These results suggest that photoexcitation of ring hexamers and photoionisation followed by ejection of protons play synergistic roles in the assembly of the EZ phase. Pollack and colleagues believe that the infrared radiation, though normally insufficient to break OH bonds, can nevertheless work via resonance induced dissociation of large hydrogen-bonded networks.

Comment: Ring hexamers bring in mind the crucial role of aromatic cycles in TGD inspired model of DNA as topological quantum computer which leads also to a model of ADP↔ ATP transition involving reconnection of magnetic flux tubes and having also information theoretic interpretation as a change of the topology of the braid structure defining topological quantum computer program [K5]. Magnetic flux tubes carrying dark electrons begin from these and can end up to other bio-molecules or water. Just a guess: could they end on ring hexamers?

Summary

The findings suggest additional details to the TGD based view about living matter.

1. The kicking of electrons or protons or both of them to a larger space-time sheet would be the first step in photosynthesis as I indeed suggested for years ago. The energy of 3100 nm photons indeed corresponds to that for the fundamental metabolic energy quantum. I have also proposed this process to be a fundamental step also in bio-catalysis: the temporary dropping of electron or proton of the catalyst molecule could provide the energy helping the reacting molecules to overcome the potential wall preventing the reaction from running. This metabolic coin could be returned to catalyst with high enough probability or the photons exchanged could be virtual.

   In many-sheeted space-time particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries of space-time sheet of a given system. Also p-adic phase transition increasing the size of the space-time sheet could take place and the liberated energy would correspond to the reduction of zero point kinetic energy. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant h_{eff} so that cyclotron energy would be liberated.

2. The findings suggest also a mechanism for how solar radiation generates proto cells or their precedessors. The resulting phases of water have size extending to those for largest cells and the water could involve a gel like phase in which magnetic flux tubes containing dark matter could play a key role and eventually lead to quantum computer like behavior [K5]. The kicking of electrons (or protons) to smaller space-time sheet would induce ionization at given space-time sheet so that electric potential difference would result. The magnitude of the potential difference is of a correct order of magnitude. Cell membrane scale is present as a p-adic length scale for the space-time sheet of electrons before the kicking to the smaller space-time sheet and these space-time sheets could act as templates for the formation of cell membrane.

3. Interestingly, TGD based model of high T_c super conductivity predicts that both cell membrane length scale and size scale of cell are involved with the super-conductivity [K25]. Cell membrane acts as a Josephson junction in TGD based model of cell membrane, nerve pulse, and EEG.

2.7.4 A Model For Chiral Selection

Chiral selection of bio-molecules is one of the basic mysteries of biology and it is interesting to see whether the existing bits of data combined with vision about quantum TGD could help to build a coherent picture about the situation. Let us first try to identify the most important pieces of the puzzle.

1. Chiral selection requires parity breaking in the scale of biomolecules. Standard model predicts parity breaking interactions but the effects are extremely small above intermediate boson length scale which is by a factor 10^{-7} shorter than atomic length scale. The proposed

solution of the problem is that dark variants of intermediate gauge bosons are in question so that the Compton lengths of intermediate gauge bosons are scaled up by a factor $r = \hbar/\hbar_0$. Below the dark Compton length weak gauge bosons would be effectively massless and above it possess ordinary masses. Large parity breaking effects induced by dark intermediate gauge bosons would be possible.

2. For instance, for $r = 2^{44}$ for which EEG photons have energies just above thermal threshold at room temperature, the effective p-adic length scale would correspond to $L(k)$, $k = 89 + 44 = 133$ of about .2 Angstrom. This scale in turn would scale up to $L(133 + 44 = 177)$. Secondary p-adic length scale assignable to $k = 89$ which is important in zero energy ontology would correspond to $k = 2 \times 89 = 178$ which corresponds to about $L(178) \simeq 100$ μm, the length scale assignable to large cells and the thickness of water layers in the experiment of Pollack.

3. Parity breaking interaction is associated with spin and the interaction energy of form $ks \cdot E_Z$, where s is the spin of particle and E_Z is Z^0 electric field. Classical induced gauge fields are very strongly correlated in TGD since they are expressible in terms of four CP_2 coordinates and their gradients. Hence classical electromagnetic field E is in the generic case accompanied by classical Z^0 field $E_Z = aE$. This means that if there is classical electromagnetic field and charge density at the dark space-time sheet, large parity breaking effect is possible at the level of spin. The induced Z^0 electric field could force the spins to become parallel and in this manner induce also magnetization.

The crucial finding about which I learned three years ago is that L glutamate is more stable than R glutamate in water and that heavy water does not induce this effect [I146]. This suggests a connection with Pollack-Zheng effect [D72]. Heavy water nuclei have vanishing spin whereas hydrogen nuclei have spin 1/2 so that H_2 in water molecules can be in spin singlet or triplet states (para and orto configurations). Could the nuclear spin of water molecules somehow induce parity breaking and the magnetic interaction distinguishing between these molecules?

1. Suppose that bio-molecules in question have magnetic moment and water carries magnetic field, most naturally at dark magnetic flux tubes. The parity breaking interaction energy $-p \cdot E$ with dark electric field remains invariant under reflection and rotation of π changing the orientation of the mirror image of the molecule with respect to electric field. The interaction energy with magnetic field however changes its sign since magnetic moment is not affected by the reflection but changes direction under rotation. The angular momentum of the molecule responsible for the magnetic moment can of course change sign but since the transformation involves acts on angular momenta only, it is not a symmetry of entire system. Indeed, if there is interaction between angular momentum degrees of freedom and geometric degrees of freedom the magnetic interaction energy for the mirror image is different. Suppose that the breaking of reflection symmetry induced by the chirality of the molecule induces internal electric field E_{int}. The parity breaking interaction energy $ks \cdot E_{int}$ would indeed break the symmetry in the transformation changing the directions of angular momenta and spins.

2. It deserves to be emphasize that the parity breaking of the molecule itself would induce the symmetry breaking if molecule possesses dark magnetic body. One can actually imagine a cascade of parity breakings proceeding from shorter to longer length scales in this manner.

3. The mechanism creating electric field could be the charging of water, perhaps by the Pollack-Zheng mechanism and having in TGD framework an interpretation as a basic mechanism storing the energy of sunlight to metabolic energy (kicking of electrons and/or protons to a smaller space-time sheet so that oppositely charge space-time sheets emerge as a consequence). A direct connection with metabolism would be admittedly a highly satisfactory feature of the mechanism.

4. Parity breaking energy $ks \cdot E$ for say dark protons assignable to hydrogen nuclei of bio-molecules in the internal electric field of the molecule or dark protons of water molecules in the electric field induced by Pollack-Zheng effect [D72] does not change sign under the reflection of the molecule so that spin polarization independent of chirality could result form both water molecules in crystal like phase and for bio-molecules possessing dark protons (and

dark hydrogen atoms). This could in turn serve as a seed for magnetization essential for the existence of dark magnetic flux tubes.

If water is replaced with heavy water there is no difference between L and R. What distinction H and D could explain this difference?

1. The basic difference between water and heavy water nuclei is that for water nucleus is just proton having spin $1/2$ so that H_2 in water molecule can be in spin triplet and singlet states. Fractions of the two states are $3/4$ and $1/4$ in the absence of external magnetic field.

2. On the other hand, in atto-second time scale (corresponding length scale is 3 Angstroms) water is known to behave effectively as $H_{1.5}O$. A possible explanation is that $1/4$: th of H nuclei/atoms are effectively dark having large Planck constant. The dark protons cannot correspond to H_2 in spin singlet state since the interaction energy $ks \cdot E$ would be small in this case. Dark spin triplet states of H_2 could however induce parity breaking in water and make crystal like water phase both electret and magnet. If the spin $s_z = 1$ with negative interaction energy with E becomes dark then $1/4$ of hydrogen atoms would be dark and $H_{1.5}O$ formula would hold true. For D_2O this mechanism would not work.

3. The model for homeopathy led to the idea that dark nuclei consisting of scale up variants of nucleons possibly having size of order atomic length scale could be crucial for understanding living matter. The states of nucleons correspond naturally to those DNA, RNA, and aminocids and vertebrate genetic code emerges naturally with DNA code word replaced with 3 quark state with entanglement between the quarks representing the information. Could it be that dark protons of water combine to form dark nuclei providing a fundamental representation of the genetic code and could the spin of protons induce electro-weak chiral symmetry breaking. Also now this mechanism fails for D_2O.

2.8 New findings related to the chiral selection

I learned of very interesting empirical findings related to the chiral selection of biomolecules (see the popular article). The article "Enantioselective Adsorption on Magnetic Surfaces" of Mohammad Reza Safari et al [**?**] is published in the journal Advanced Materials (2023).

2.8.1 The findings

Consider first the experimental arrangement and findings.

1. There is a copper conductor with a strong electric field in the normal direction of the conductor. Cu is not a magnetic substance. There are very thin Cobalt islands at the surface of the conductor. Cobalt is a magnetic metal. There are two options: magnetization direction is North or South and it corresponds to either up or down. North up and South down are the options and these could correspond to different chiralities somehow.

2. The molecules drift to the Cobalt islands and, depending on their chirality, prefer to bind to either south-up or north-up Cobalt islands. Are the magnetic fields of islands helical and possess a definite chirality? Does the magnetic chirality tend to be the same or opposite to that of the enantiomer that binds to it?

3. The effect is reported to occur already before the Cobalt islands in the drifting of molecules to the Cobalt islands. What does this mean? Counterparts of magnetic fields are not present.

4. It is also found that electrons with a given spin direction prefer to tunnel through the molecules in a direction which correlates with the chirality.

2.8.2 TGD view of the findings

These are highly interesting findings providing new empirical hints about the nature of chiral selection in living matter. Weak interactions are really weak and parity violation effects should be extremely small above weak scale so that the standard model fails to explain chiral selection.

TGD view of dark matter and chiral selection

The TGD view of dark matter would make possible chiral selection.

1. Chiral selection is one of the key empirical facts supporting the TGD prediction of a hierarchy of phases of ordinary matter predicted by the number theoretical vision of TGD [L87, L46, L145, L116, L119, L127]. These phases are labelled by effective Planck constant h_{eff}, which is essentially the dimension of an algebraic extension of rationals.

2. The predicted huge values of h_{eff} assignable to classical gravitational and electric fields of astrophysical objects [L127] mean that weak interactions become as strong as em interactions below the scale up Compton length of weak bosons, which, being proportional to h_{eff}, can be as large as cell size. This amplifies parity violation effects visible for instance in hydrodynamics [K2].

3. Large h_{eff} phases behave like dark matter: they do not however explain galactic dark matter, which in the TGD framework is dark energy assignable to cosmic strings (no halo and an automatic prediction of the flat velocity spectrum). Instead, large h_{eff} phases solve the missing baryon problem [L139]. The density of baryons has decreased in cosmic evolution (having biological evolution as a particular aspect) and the explanation is that evolution as unavoidable increase of algebraic complexity measured by h_{eff} has transformed them to $h_{eff} \geq h$ phases at the magnetic bodies (thickened cosmic string world sheets, 4-D objects), in particular those involved with living matter.

4. The large value of h_{eff} has, besides number theoretical interpretation [L138], a geometric interpretation. Space-time surface can be regarded as manys-sheeted over both M^4 and CP_2. In the first case the CP_2 coordinates are many-valued functions of M^4 coordinates. In the latter case M^4 coordinates are many-valued functions of CP_2 coordinates. This case is highly interesting in the case of quantum biology. Since a connected space-time surface defines the quantum coherence region, an ensemble of, say, monopole flux tubes can define a quantum coherent region in the latter case: one simply has an analog of Bose-Einstein condensate of monopole flux tubes.

The flux tube condensate as a covering of CP_2 means a dramatic deviation from the QFT picture and is a central notion in the applications of quantum TGD to biology. Therefore some examples are in order.

1. Fermi liquid description of electrons relies on the notion of a quasiparticle as an electron plus excitations of various kinds created by its propagation in the lattice. In some systems this description fails and these systems would. have a natural description in terms of space-time surfaces which are multiple coverings of CP_2, say flux tube condensates.

2. In high Tc superconductors and bio-superconductors [K89, K90] the space-time surface could correspond to this kind of flux tube condensates and Cooper pairs would be fermion pairs with members at separate flux tubes. The connectedness of the space-time surface having about $h_{eff}/h = n$ flux tubes would correlate the fermions.

3. Bogoliubov quasiparticles related to superconductors are regarded as superpositions of electron excitation and hole. The problem is that they have an ill-defined fermion number. In TGD, they would correspond to superpositions of a dark electron accompanied by a hole which it has left behind and therefore having a well-defined fermion number. Bogoliubov quasiparticle is indeed what can be seen using the existing experimental tools and physical understanding.

4. Strange metals would be an example of a system having no description using quasiparticles, as the linear dependence of the resistance at low temperatures demonstrates. I have considered a description of them in terms of Cooper pairs at short closed flux tubes [K89, K105]: this would however suggest a vanishing resistance in an ideal situation. Something seems to go wrong.

An alternative description could be in terms of superpositions of dark electrons and holes assignable to the flux tube condensate. Strange metal is between Fermi liquid and superconductor: this conforms with the fact that strange metals are quantum critical systems. The transition to high Tc superconductivity is preceded by a transition to a phase in which something resembling Cooper pairs is present.

A natural looking interpretation would be in terms of a flux tube condensate and pairs of dark and ordinary electrons. Also now the flux tubes could be short. In [K31], I have considered the possibility that high Tc superconductors could be this kind of "half-superconductors" but this option seems to be wrong.

The phase transitions between "half-superconductivity" and superconductivity could play a central rol also in living matter.

A more detailed view of chiral selection in the TGD framework

Before proceeding to a detailed model, one must understand how the large parity violation required by the chiral selection could emerge in the TGD framework.

1. Since the Kähler action does not contain the induced $SU(2)_L$ weak fields, there should be no direct parity violation at the space-time level. The geometric parity violation as a chiral selection of bio-molecules could be however induced from the fermionic dynamics induced by the modified Dirac action determined completely the bosonic action. The twistor lift of TGD [K114, L52, K16] suggest that this action is a sum of volume term and Kähler action.

   Holography realized as generalized holomorphy implies that solutions are minimal surfaces irrespective of action and only the conditions at boundaries and singularities distinguish between different general coordinate invariant actions constructible using the induced geometry.

2. In the standard physics framework one could argue that Chern-Simons term relates to the parity violation. Now the situation is not so straightforward since parity violation for the weak interactions basically occurs at the level of $M^4 \times CP_2$ and is induced to the space-time level.

   Chern-Simons-Kähler (CSK) action emerges from the topological istanton term $J \wedge J$ in the exponent defining vacuum functional [K55, K99, L136, K123]. The CSK term is naturally imaginary whereas the non-topological term defining the Kähler function as Kähler action would be real. The CSK term contains two parts corresponding to M^4 and CP_2 parts of the Kähler form. Neither Kähler action nor CSK action contain the induced $SU(2)_L$ gauge potentials so that parity violation directly induced by weak interactions is not present. CSK action is associated with partonic orbits carrying fermion lines identified as the light-like boundaries of the space-time surface and the interfaces of Euclidean and Minkowskian regions of the space-time surface.

3. CSK term contributes also a term to the modified Dirac action [K123] [L140], which is fixed completely by the bosonic action defining the space-time surfaces as a Bohr orbit-like preferred extremals satisfying holography, which reduces to a generalized holomorphy [L136].

   What is crucial is that the covariant derivative acting on the induced spinor fields, obtained by restricting the second quantized H spinor fields to the space-time surface, contains the parity violation weak interaction term so that the parity violation at the level of elementary fermions emerges through it. This parity violation must induce the geometric parity violation at the level of the geometry of space-time surfaces distinguishing between different chiralities in dark weak scales.

4. The model of anomalous electron-positron pairs produced in heavy nucleus collisions [K117] assigns dark leptopion condensate to the non-vanishing of the Chern-Simons term requiring that the induced Kähler and electric fields are not orthogonal. The condition that the dark leptopion Compton wavelength, which is 1/2 of dark electron Compton length, should be of the order of the thickness of the electric flux tube. One must assume that the leptopions are dark in the sense that they have $h_{eff} \neq h$ since otherwise they would be produced in the decays of weak bosons.

It will be found that the model provides further support for a generalization of the Pollack effect [I92, L23, I147, I126]: instead of protons of water molecules, electrons at the conductor surface would be transformed to dark electrons at the magnetic monopole flux tubes. This suggests also a generalization [L119] of the dark genetic code [L75, L101, L108, L126]. For this generalization dark proton triplets as a representation of codons would be replaced with dark electron triplets. The universality of the realization of the dark genetic code in terms of the completely unique icosa tetrahedral tessellation of hyperbolic space H^3 supports this idea.

2.8.3   A TGD based model for the findings

Consider now a concrete model for the findings in the TGD framework.

1. A good guess is that the molecular monopole flux tubes of the molecules and of the magnetic fields assignable with the Cobalt islands tend to have the same chirality. This would generalize the chiral selection from the level of biomolecules to the level of dark monopole flux tubes. Some kind of condensate of flux tubes of the same chirality as a long scale parity violation would be in question.

2. In the TGD framework, the North up and South up magnetic fields could correspond to helical monopole flux tubes of opposite chiralities. The helical structure is essential and could relate directly to the requirement that the flux tube is closed: one could have a shape of flattened square for which the long sides form a double helix. This would be the case also for DNA.

3. Parity violation requires a large value of h_{eff}. Dark Z (and W) bosons could generate a large parity violation. Dark Z boson Compton length of order biological scale. The very large value of h_{eff} would give the needed large energy splitting between generalized cyclotron energies at the dark flux tube and induce chiral selection.

   Gravitational flux tubes of the Earth's gravitational field or solar gravitational field would do the job. By the Equivalence Principle, the gravitational Compton length $\Lambda_{gr,E} = .5$ cm for Earth does not depend on the particle mass and looks like a promising scale. Also the cyclotron energies are independent of the mass of the charged particle since $\hbar_{gr}$ is proportional to particle mass m and cyclotron frequency to $1/m$.

4. Also the electric field of the Copper surface should have an important role. The electric field orthogonal to Cu conductor would correspond to electric flux tubes. The consistency condition for the electric flux tube thickness with charged at the bottom (conductor) reads as $\Lambda_{em}(d) \sim d$. $\hbar_{em} = Ne^2/\beta_0$, N the number of electrons at the bottom. There is roughly one electron per atom. $N \sim 10^4$ per flux tube area of 100 nm^2 having radius about 10 nm. $\Lambda_{em} = Ne^2/\beta_0\lambda_e$ is about 1 nm for $\beta_0 = 1$. The value of $\hbar_{em}$ are rather small and it seems that it cannot contribute to the chiral selection. One can however consider also the electric field of Earth, and in this case the situation could be different.

The effect occurs already before the Cobalt islands. Furthermore, electrons with a given spin direction prefer to tunnel through the molecules in a direction dicrated by the chirality. What could this mean?

1. The counterparts of magnetic fields are present as dark magnetic fields inside the magnetic bodies of the drifting molecules. Suppose that dark molecular gravitational monopole tubes are indeed present and give rise to closed spin current loops with a direction determined by the chirality of the molecule. This would give rise to the large parity violation but how to understand the occurrence of the effect already before the Cobalt islands?

2. Could one assign a definite chirality also to the electric flux tubes assignable to the Cu surface and assume that the molecular chirality tends to be the same (or opposite) to this chirality? Do also these closed monopole flux tubes carry dark electric current?

   The spin direction of the current carrying electrons would correlate with the magnetization direction so that the magnetic body of the molecule would prefer a pairing with the electric body with a preferred spin direction. The preferred pairing would explain the drift to a correct Cobalt island: the paths leading to the Cobalt island would be more probable.

3. In the case of water, the Pollack effect [I92, L23, I147, I126] transfers part of the protons of water molecules to dark protons at monopole flux tubes. Now there are no protons available.

   Does this require a generalization of the Pollack effect? Could the electric flux tubes be gravitational flux tubes carrying electrons instead of protons? Gravitational Compton length would be the same. Could electronic Pollack effect for conductors as a dual of Pollack effect for water be in question.

4. In the TGD inspired quantum biology, one assigns genetic code with dark proton triplets. Could one assign a dark realization of the genetic code to dark electron triplets? Could the electric counterparts of gravitational flux tubes carrying dark realization of the genetic code define dark genetic code? Codons would correspond to dark electron triplets instead of dark proton triplets. Could the analogs of the ordinary genetic codons correspond to the triplets of electron holes at the conductor surface?

   The TGD based vision about universal genetic code suggests the existence of a 2-D analog of DNA realized in terms of mathematically completely unique hyperbolic icosa tetrahedral tessellation. Could this genetic code be associated with the metal surfaces? The implications of this hidden genetic code for computers might be rather dramatic.

2.8.4 Burning Water And Photosynthesis

For a physicist liberated from the blind belief in reductionism, biology transforms to a single gigantic anomaly about which recent day physics cannot say much. During years I have constructed several models for these anomalies helping to develop a more detailed view about how the new physics predicted by quantum TGD could allow to understand biology and consciousness.

The basic problem is of course the absence of systematic experimentation so that it is possible to imagine many new physics scenarios. For this reason the article series of Mae-Wan Ho [D64, D62, D60, D63] in ISIS was a very pleasant surprise, and already now has helped considerably in the attempts to develop the ideas further.

The first article "Water electric" [D64] told about the formation of exclusion zones around hydrophilic surfaces, typically gels in the experiments considered [D72]. The zones were in potential of about 100 meV with respect to surroundings (same order of magnitude as membrane potential) and had thickness ranging to hundreds of micrometers (the size of a large cell): the standard physics would suggests only few molecular layers instead of millions. Sunlight induced the effect. This finding allow to develop TGD based vision about how proto cells emerged and also the model for chiral selection in living matter by combining the finding with the anomalies of water about which I had learned earlier.

The article "Can water burn?" [D60] tells about the discovery of John Kanzius - a retired broadcast engineer and inventor. Kanzius found that water literally burns if subjected to a radio frequency radiation at frequency of 13.56 MHz [D1]. The mystery is of course how so low frequency can induce burning. The article "The body does burn water" [D63] notices that plant cells burn water routinely in photosynthesis and that also animal cells burn water but the purpose is now to generate hydrogen peroxide which kills bacteria (some readers might recall from childhood how hydrogen peroxide was used to sterilize wounds!). Hence the understanding of how water burns is very relevant for the understanding of photosynthesis and even workings of the immune system.

Living matter burns water routinely

Photosynthesis burns water by decomposing water to hydrogen and oxygen and liberating oxygen. Oxygen from CO_2 in atmosphere combines with the oxygen of H_2O to form O_2 molecules whereas H from H_2O combines with carbon to form hydrocarbons serving as energy sources for animals which in turn produce CO_2. This process is fundamental for aerobic life. There is also a simpler variant of photosynthesis in which oxygen is not produced and applied by an-aerobic life forms. The article "Living with Oxygen" by Mae-Wan Ho gives a nice overall view about the role of oxygen [D61]. As a matter fact, also animals burn water but they do this to produce hydrogen peroxide H_2O_2 which kills very effectively bacteria.

Burning of water has been studied as a potential solution for how to utilize the solar energy to produce hydrogen serving as a natural fuel [D62]. The reaction $O_2 + H_2 \rightarrow 2H_2O$ occurs

spontaneously and liberates energy of about 1.23 eV. The reverse process $2H_2 \rightarrow H_2O_2 + H_2$ in the presence of sunlight means burning of water, and could provide the manner to store solar energy. The basic reaction $2H_2O + 4h\nu \leftrightarrow H_2O_2 + H_2$ stores the energy of four photons. What really happens in this process is far from being completely understood. Quite generally, the mechanisms making possible extreme efficiency of bio-catalysis remain poorly understood. Here new physics might be involved. I have discussed models for photosynthesis and $ADP \leftrightarrow ATP$ process involved with the utilization of the biochemical energy already earlier [K57].

How water could burn in TGD Universe?

The new results could help to develop a more detailed model about what happens in photosynthesis. The simplest TGD inspired sketch for what might happen in the burning of water goes as follows.

1. Assume that 1/4 of water molecules are partially dark (in sense of nonstandard value of Planck constant) or at least at larger space-time sheets in atto-second scale [D58, D55, D68, D36]. This would explain the $H_{1.5}O$ formula explaining the results of neutron diffraction and electron scattering.

2. The question is what this exotic fraction of water precisely is. The models for water electret, exclusion zones and chiral selection lead to concrete ideas about this. Electrons assignable to the H atoms of (partially) dark H_2O reside at space-time sheet $k_e = 151$ (this p-adic length scale corresponds to 10 nm, the thickness of cell membrane). At least the hydrogen atom for this fraction of water molecules is exotic and findings from neutron and electron scattering suggest that both proton and electron are at non-standard space-time sheets but not necessarily at the same space-time sheet. The model for the burning requires that electron and proton are at different space-time sheets in the initial situation.

3. Suppose all four electrons are kicked to the space-time sheet of protons of the exotic hydrogen atoms labeled by k_p. This requires the energy $E_\gamma = (1 - 2^{-n})E_0(k_p)$ (the formula involves idealizations). At this space-time sheet protons and electrons are assumed to combine spontaneously to form two H_2 atoms. Oxygen atoms in turn are assumed to combine spontaneously to form O_2.

4. For $k_f = 148$ and $n = 3$ minimum energy needed would be $4E_\gamma = 4 \times .4 = 1.6$ eV. For $k_p = 149$ (thickness of lipid layer) and $n = 2$ one would have $4E_\gamma = 4 \times .3462 = 1.385$ eV whereas $H_2O_2 + H_2 \rightarrow 2H_2O$ liberates energy 1.23 eV. Therefore the model in which electrons are at cell membrane space-time sheet and protons at the space-time sheet assignable to single lipid layer of cell membrane suggests itself. This would also mean that the basic length scales of cell are already present in the structure of water. Notice that there is no need to assume that Planck constant differs from its standard value.

There is no need to add, that the model is an unashamed oversimplification of the reality. It might however catch the core mechanism of photosynthesis.

Burning of salt water induced by RF radiation

Engineer John Kanzius has made a strange discovery [D1]: salt water in the test tube radiated by radio waves at harmonics of a frequency f=13.56 MHz burns. Temperatures about 1500 K, which correspond to .15 eV energy have been reported. One can irradiate also hand but nothing happens. The original discovery of Kanzius was the finding that radio waves could be used to cure cancer by destroying the cancer cells. The proposal is that this effect might provide new energy source by liberating chemical energy in an exceptionally effective manner. The power is about 200 W so that the power used could explain the effect if it is absorbed in resonance like manner by salt water.

Mae-Wan Ho's article "Can water Burn?" [D60] provides new information about burning salt water [D1], in particular reports that the experiments have been replicated. The water is irradiated using polarized radio frequency light at frequency 13.56 MHz. The energy of radio frequency quantum is $E_{rf} = .561 \times 10^{-7}$ eV and provides only a minor fraction $E_{rf}/E = .436 \times 10^{-7}$ of the needed energy which is $E = 1.23$ eV for single $2H_2O \rightarrow H_2O_2 + H_2$ event. The structure of water has been found to change, in particular something happens to O-H bonds. The Raman spectrum

of the water has changed in the energy range $[0.37, 0.43]$ eV. Recall that the range of metabolic energy quanta $E(k, n) = (1 - 2^{-n})E_0(k)$ varies for electron in the range $[.35, .46]$ eV in the model for the formation of exclusion zone induced by light. Therefore the photons assigned to changes in Raman spectrum might be associated with the transfer of electrons between space-time sheets.

The energies of photons involved are very small, multiples of 5.6×10^{-8} eV and their effect should be very small since it is difficult to imagine what resonant molecular transition could cause the effect. This leads to the question whether the radio wave beam could contain a considerable fraction of dark photons for which Planck constant is larger so that the energy of photons is much larger. The underlying mechanism would be phase transition of dark photons with large Planck constant to ordinary photons with shorter wavelength coupling resonantly to some molecular degrees of freedom and inducing the heating. Microwave oven of course comes in mind immediately.

As I made this proposal, I did not realize the connection with photosynthesis and actual burning of water. The recent experimental findings suggest that dark radio frequency photons transform to photons inducing splitting of water as in photosynthesis so that one should have $r = \hbar/\hbar_0 = E_{rf}/4E$. One could say that large number of radio wave photons combine to form a single bundle of photons forming a structure analogous to what mathematician calls covering space. In the burning event the dark photon would transform to ordinary photon with the same energy. This process would thus transform low energy photons to high energy protons with the ratio $r = \hbar/\hbar_0$.

Therefore the mechanism for the burning of water in the experiment of Kanzius could be a simple modification of the mechanism behind burning of water in photosynthesis.

1. Some fraction of dark radio frequency photons are dark or are transformed to dark photons in water and have energies around the energy needed to kick electrons to smaller space-time sheets .4 eV. After this they are transformed to ordinary photons and induce the above process. Their in-elastic scattering from molecules (that is Raman scattering) explains the observation of Raman scattered photons. For a fixed value of $\hbar$ the process would occur in resonant manner since only few metabolic quanta are allowed.

2. How dark radio frequency photons could be present or could be produced in water? Cyclotron radiation assignable to say electrons in magnetic field comes in mind. If the cyclotron radiation is associated with electrons it requires a magnetic field of 4.8 Gauss the cyclotron frequency is 13.56 MHz. This is roughly ten times the nominal value $B_E = .5$ Gauss of the Earth's magnetic field and 24 times the value of dark magnetic field $B_d = .4 B_E = .2$ Gauss needed to explain the effects of ELF em fields on vertebrate brain. Maybe dark matter at flux tubes of Earth's magnetic field with Planck constant equal to $\hbar/\hbar_0 = \frac{1}{4}\frac{E}{E_{rf}}$ transforms radio frequency photons to dark photons or induces resonantly the generation of cyclotron photons, which in turn leak out from magnetic flux tubes and form ordinary photons inducing the burning of water. $E_\gamma = .4$ eV would give $\hbar/\hbar_0 == 1.063 \times 2^{21}$ and $E_\gamma = .36$ eV would give $\hbar/\hbar_0 = .920 \times 2^{21}$.

3. Magnetic fields of magnitude .2 Gauss are in central role in TGD based model of living matter and there are excellent reasons to expect that this mechanism could be involved also with processes involved with living matter. There is indeed evidence for this. The experiments of Gariaev demonstrated that the irradiation of DNA with 2 eV laser photons (which correspond to one particular metabolic energy quantum) induced generation of radio wave photons having unexpected effects on living matter (enhanced metabolic activity) [I55], and that even a realization of genetic code in terms of the time variation of polarization direction could be involved. TGD based model [K23, K116] identifies radio-wave photons as dark photons with same energy as possessed by incoming visible photons so that a transformation of ordinary photons to dark photons would have been in question. The model assumed hierarchy of values of magnetic fields in accordance with the idea about onion like structure of the magnetic body.

There are several questions to be answered.

1. Is there some trivial explanation for why salt must be present or is new physics involved also here. What comes in mind are Cooper pairs dark Na^+ ions (or their exotic counterparts which are bosons) carrying Josephson currents through the cell membrane in the model of the

cell membrane as a Josephson junction which is almost vacuum extremal of Kähler action. In the experimental arrangement leading to the generation of exclusion zones the pH of water was important control factor, and it might be that the presence of salt has an analogous role to that of protons.

2. Does this effect occur also for solutions of other molecules and other solutes than water? This can be tested since the rotational spectra are readily calculable from data which can be found at net.

3. Are the radio wave photons dark or does water - which is very special kind of liquid - induce the transformation of ordinary radio wave photons to dark photons by fusing $r = \hbar/\hbar_0$ radio wave massless extremals (MEs) to single ME. Does this transformation occur for all frequencies? This kind of transformation might play a key role in transforming ordinary EEG photons to dark photons and partially explain the special role of water in living systems.

4. Why the radiation does not induce spontaneous combustion of living matter which contains salt. And why cancer cells seem to burn: is salt concentration higher inside them? As a matter fact, there are reports about [D7]. One might hope that there is a mechanism inhibiting this since otherwise military would be soon developing new horror weapons unless it is doing this already now. Is it that most of salt is ionized to Na^+ and Cl^- ions so that spontaneous combustion can be avoided? And how this relates to the sensation of spontaneous burning [D6] - a very painful sensation that some part of body is burning?

5. Is the energy heating solely due to rotational excitations? It might be that also a "dropping" of ions to larger space-time sheets is induced by the process and liberates zero point kinetic energy. The dropping of proton from k=137 (k=139) atomic space-time sheet liberates about .5 eV (0.125 eV). The measured temperature corresponds to the energy .15 eV. This dropping is an essential element in the ealier of remote metabolism and provides universal metabolic energy quanta. It is also involved with TGD based models of "free energy" phenomena. No perpetuum mobile is predicted since there must be a mechanism driving the dropped ions back to the original space-time sheets.

   In many-sheeted space-time particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries of space-time sheet of a given system. Also p-adic phase transition increasing the size of the space-time sheet could take place and the liberated energy would correspond to the reduction of zero point kinetic energy. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant h_{eff} so that cyclotron energy would be liberated.

6. The electrolysis of water and also cavitation produces what is known as Brown's gas which should consist of water vapour and there might be a connection to the burning of salt water. The properties of Brown's gas [H9] however do not support this interpretation: for instance, Brown's gas has temperature of about 130 C but is able to melt metals so that some un-known mechanism liberating energy must be involved explaining also the claims about over-unity energy production in water splitting using electrolysis. TGD inspired model for Brown's gas [K58] suggests that activated water and Brown's gas correspond to same phase involving polymer sequences formed from exotic water molecules for which one hydrogen nucleus is dark and defining the analogs of basic biopolymers. The bond binding protons to a polymer like sequence would serve as the counterpart of covalent bond.

   One also ends up with a more detailed TGD inspired view about basic mechanism of metabolism in living matter predicting a tight correlation between p-adic length scale hypothesis and hierarchy of Planck constants. The model differs in some aspects from the rough models considered hitherto assuming that metabolic energy is liberated as zero point kinetic energy when particle drops to a larger space-time sheet or as cyclotron energy when cyclotron quantum number decreases. Now a phase transition increasing the p-adic length scale of the space-time surface would liberate either kinetic energy of cyclotron energy. Quantum numbers would not change: rather, t the scale appearing as a parameter in the expression of

kinetic or cyclotron energy would change adiabatically and in this manner guarantee coherence. Also a phase transition in which the changes of scale due to a reduction of Planck constant and increase of the p-adic length scale compensate each other liberate metabolic energy.

Recall that one of the empirical motivations for the hierarchy of Planck constants came from the observed quantum like effects of ELF em fields at EEG frequencies on vertebrate brain and also from the correlation of EEG with brain function and contents of consciousness difficult to understand since the energies of EEG photons are ridiculously small and should be masked by thermal noise.

2.8.5 How Bio-Polymers Were Associated With Their Dark Counterparts?

The experiments of Pollack [L23] demonstrating what he calls fourth phase of water is characterized by negatively charged regions - exclusion zones (EZs). The stoichiometry of water inside EZ is $H_{1.5}O$. TGD based model assumes that part of protons in these regions have been transferred to magnetic flux tubes were they form sequences identifiable as dark nuclei. The surprising finding is that a simple model for dark proton allows to assign its states to multiplets for which numbers of states are those assignable to DNA, RNA, and tRNA codons, plus amino-acids. Also the vertebrate genetic code can be realized in a simple manner. This leads to a vision about prebiotic life as dark life evolved in water before the ordinary life. Dark life would be present also in ordinary life forms.

If one believes that dark proton sequences [K53] define the counterparts of DNA, RNA, tRNA, and amino-acids realized at magnetic flux tubes, the question is how this form of life was transformed to the bio-chemical life.

The article "Hydrogen cyanide polymers, comets and the origin of life" (`http://tinyurl.com/ybfuwneq`, thanks to Ulla for the link) helped me to discover a new big gap in my knowledge about biology and this in turn led to a more detailed vision about how the transition could have taken place. HCN is everywhere and Miller demonstrated in his classic experiments that 11 out of 20 amino-acids emerged in presence of HCN. It has been later found that well over 20 amino-acids were produced. (`http://tinyurl.com/y9at46fe`). In my own belief system amino-acids could have appeared first as concrete something "real" and DNA as symbolic representations of this something "real". First at dark matter level and then biochemically.

In TGD Universe one can imagine - with inspiration coming partially from Pollack's experiments [L23] (`http://tinyurl.com/oyhstc2`) - that dark variants DNA, RNA and amino-acids were realized first as dark proton sequences at flux tubes- dark nuclei - I call them just dark DNA, RNA and amino-acids although dark proton sequences are in question. The genetic machinery involving translation and transcription was realized as dark variant and dark DNA was a symbolic representation for dark amino-acids.

How did this dark life give rise to bio-chemical life as its image? This is the question! I can only imagine some further questions.

1. Was this process like master teaching to a student a skill? Master does it first, and then student mimics. If so, the emergence of amino-acids, mRNA and DNA polymers would *not* have been purely chemical process. Dark variants of these polymers would have served as templates for the formation of ordinary basic biopolymers, for transcription, and for translation. These templates might have been necessary in order to generate long RNA and DNA sequences: mere chemistry might have not been able to achieve this. Without dark polymers one obtains only bio-monomers, with dark polymers as template one obtains also bio-polymers. Dark polymers would have been the plan, biopolymers the stuff used to build.

2. Are dark DNA, RNA, amino-acids, etc indeed still there and form binary structures with their biochemical variants as I have indeed proposed?

3. Are dark translation and transcription processes still an essential part of ordinary translation and transcription? Master-student metaphor suggest that these dark processes actually induce them just like replication of magnetic body could induce the replication of DNA or cell. Visible chemistry would only make visible the deeper "dark chemistry". Apologies for all biochemists who have done heroic work in revealing chemical reaction paths!

How the process assigning biochemical life to dark life could have proceeded? The minimalistic guess is that the only thing that happened was that dark life made itself gradually visible! As a consciousness theoretician I have a temptation to see religious statements as hidden metaphors, at least they provide an excellent manner to irritate skeptics: Dark matter - the "God" made us-the biological life - to its own image.

1. First dark amino-acid sequences were accompanied by ordinary amino-acid sequences so that the dark translation process had now a visible outcome. At this step the presence of HCN was crucial and made the step unavoidable. Also the presence of template was necessary.

2. Dark mRNA got a visible counterpart in the same manner: the presence of template made possible long RNA polymers. The translation remained basically dark process but made visible by mRNA.

3. Dark DNA got a visible companion: again the presence of the template was - and still is - crucial.

What about generation of DNA and RNA? It is known that in reducing atmosphere DNA and RNA nucleobasis are obtained in an environment believed to mimick prebiotic situation: the presence of HCN and ammonia are necessary (`http://tinyurl.com/y9at46fe`). Reducing atmosphere `http://tinyurl.com/yc62g22f` does not oxidize, in other worlds does not contain oxygen and other oxidizing agents and can contain also actively reducing agents such as hydrogen, carbon monoxide. There are however some problems.

1. There is evidence that early Earth atmosphere contained less reducing molecules than thought in times of Miller. If life emerged in the underground water reservoirs as TGD strongly suggests, the usual atmosphere was absent and there are good hopes about reducing atmosphere.

2. The experiments using reducing gases besides those used in Miller's experiments produce both left and right handed polymers so that chiral selection is missing. This is not a surprise since weak interactions generate extremely small parity breaking for visible matter. If dark proton strings or even dark nuclei are involved, the Compton length of weak gauge bosons can be of the order of atomic length scale or even longer and weak interactions would be as strong as electromagnetic interactions. Therefore chiral selection becomes possible. The simplest option is that chirality selection occurred already for the helical magnetic flux tubes and induced that of biopolymers.

2.9   Water Memory And Pre-Biotic Life

Pollack's findings [L23] discussed from TGD view point in [K90, K85] provide new insights to the mechanisms of water memory and homeopathy. Also the attempts to understand the dependence of h_{eff} on parameters of the system involved provide help. This picture also suggests a more detailed vision about prebiotic life forms as analogs of exclusion zones involving charge separation leading to large value of h_{eff}.

2.9.1   Exclusion Zones As Prebiotic Cells

TGD based model model [L23], [K86] for Pollack's findings [L23] provides further guidelines.

1. Pollack *et al* discovered what they call exclusion zones and fourth gel like phase of water. The phenomenon occurs when water is bounded by gel and is irradiated with say visible light. Exclusion zones are negatively charged regions of water with positively charged environment. They act like batteries and have rather exotic properties. For instance, various impurities are repelled from exclusion zone.

2. The observed $H_{1.5}O$ stoichiometry implies that every fourth proton or hydrogen atom is dark and is transferred to the region outside the negatively charged exclusion zone. If only protons are transferred, very high negative charge density is generated. The size of the exclusion zone varies up to 100 μm and is in the range of cell sizes.

3. Dark matter corresponds in TGD Universe to phases with nonstandard value of Planck constant: $h_{eff} = n \times h$ phases at the "magnetic body" of the system (negatively charged region now). Magnetic body corresponds in Maxwell's theory to the magnetic fields generated by the system. Magnetic body consists of flux quanta (flux tubes and sheets).

4. If dark protons with say size scale of atomic size reside at flux tubes, one can assume that they form strings giving rise to dark atomic nuclei. Also ordinary nuclei consist of strings of dark protons and strings of neutrons. Various impurities are transferred from exclusion zone to the exterior suggesting that they become dark particles at magnetic flux tubes.

5. The quantum states of dark protons consist of 3 quarks and a simple model involving rotational symmetry around the axis of dark proton string predicts that the states of dark proton can be arranged into groups which correspond to DNA, RNA, amino-acids and possibly also tRNA molecules. Vertebrate genetic code can be realized as a natural correspondence between DNA/ RNA and amino-acids [L3, K53].

6. Negatively charged EZ could define a pre-biotic cell so that water would be a primitive pre-biotic life form. The voltage would be the analog of the resting potential. The transformation of dark protons to ordinary ones would liberate metabolic energy so that primitive metabolism and photosynthesis would be realized. One can also consider a more general possibility that cyclotron energies are different at flux tube portions in the interior and exterior of the EZ analogous to cell membrane. This would increase the value of the metabolic energy currency by adding to Josephson energy ZeV the difference of dark cyclotron energies proportional to h_{eff}. One expects that dark counterparts of basic bio-polymers are still present in living matter and play a fundamental role.

2.9.2 TGD View About Homeopathy, Water Memory, And Evolution Of Immune System

The following gives an attempt to build a brief sketch of TGD based model of water memory and homeopathy as it is after the input from Pollack's findings and $h_{eff} = h_{gr} = h_{em}$ hypothesis.

Summary of the basic facts and overall view

A concice summary of the basic qualitative facts about homeopathy [K53] could be following.

1. The manufacture of the homeopathic remedies consists of repeated dilution and agitation of water sample containing the molecules causing the effect which the remedy is intended to heal. This paradoxical looking healing method is based on "Alike likes alike" rule. This rules brings in mind vaccination causing immune system to develop resistance. The procedure seems to somehow store information about the presence of the molecules and this information induces immune response. Usually it is the organisms or molecules causing the disease which induce immune response.

2. The ultra-naïve and simplistic objection of skeptic is that the repeated dilution involved with the preparation of homeopathic remedy implies that the density of molecules is so small that the molecules can have absolutely no effect. Despite the fact that we live in information society, this is still the standard reaction of a typical skeptic.

3. A lot of research is done by starting from the natural idea that the electro-magnetic fields associated with the invader molecules (or more complex objects) represent the needed information and that water somehow gets imprinted by these fields. This could for instance mean that water clusters learn to reproduce radiation at frequencies characterizing the invader molecule. Benveniste is one of the most outstanding pioneers in the field [I48]. Benveniste *et al* [I49] even managed to record the VLF frequency finger print of some bio-active molecules and record them in binary form allowing to to yield the same effect as the real bio-active molecule induced. Benveniste was labelled as a fraud. The procedure used by the journal Nature to decide whether Benveniste is swindler or not brings in mind the times of inquisition. It tells a lot about attitudes of skeptics that magician Randi was one member of the jury!

4. Benveniste's work has been continued and recently HIV Nobelist Montagnier produced what might be regarded as remote replication of DNA using method very similar to that used in manufacturing homeopathic remedy [I65, I66].

The general conclusion is that the em frequencies possibly providing a representation of the molecules are rather low - in VLF region - so that frequencies assignable to molecular transitions are not in question. Cyclotron frequencies assignable to the molecules are the most natural candidates concerning physical interpretation. The corresponding photon energies are extremely low if calculated from $E = hf$ formula of standard quantum mechanics so that quantal effects in the framework of standard quantum theory do not seem to be possible.

My personal interest on water memory was sparked by the work of Cyril Smith [J27]. What I learned was what might be called scaling law of homeopathy [K53]. Somehow low frequency radiation seems to be transformed to high frequency radiation and the ratio $f_h/f_l \simeq 2 \times 10^{11}$ seems to be favored frequency ratio.

These two basic findings suggest what looks now a rather obvious approach to homeopathy in TGD framework. The basic physical objects are the magnetic bodies of the invader molecule and water molecule cluster or whatever it is what mimics the invader molecule. The information about magnetic body is represented by dark cyclotron radiation generated by the invader with frequency f_l. This dark radiation is transformed to ordinary photons with frequency f_h and energy $h_{eff}f_l = hf_h$, which is above thermal energy, most naturally in the range of bio-photon energies so that the radiation can directly induce transitions of bio-molecules. The analogs for the EZs discovered by Pollack are obvious candidates for "water molecule clusters".

The following summarizes this overall picture in more detail.

Dark photon-bio-photon connection

The idea that bio-photons are decay product of dark photons emerged from the model of EEG [K44] in terms of dark photons with energies above thermal energy. Dark photons in question would be emitted as cyclotron radiation by various particles and molecules, perhaps even macromolecules like DNA sequences. Also cell membrane would emit dark photons with frequencies, which correspond in good approximation to differences of cyclotron energies for large value of $h_{eff} = nh$ [K90, K44].

1. Bio-photons have spectrum in the visible and UV would decay products of dark cyclotron photons. If the h_{eff} of particle is proportional to its mass then the cyclotron energy spectrum is universal and does not depend on the mass of the particle at all. The original model of EEG achieved this by assuming that h_{eff} is proportional to the mass number of the atomic nucleus associated with the ion.

2. The ideas about dark matter involve two threads: $h_{eff} = n \times h$ thread motivated by biology and the thread based on the notion of gravitational Planck constant and inspired by the observation that planetary orbits seem to obey Bohr rules. $\hbar_{gr} = GMm/v_0$ is assigned to the pairs of gravimagnetic flux tubes and massless extremals making possible propagation of dark gravitons. The realization was the two threads can be combined to single thread: by Equivalence Principle h_{gr} hypothesis is needed only for microscopic objects and in this case $h_{eff} = h_{gr}$ makes sense and predicts that dark photon energies and dark particle Compton lengths do not depend on particle and that bio-photon energy spectrum is universal and in the desired range if one assumes that h_{gr} is associated with particle Earth par with v_0 the rotational velocity at the surface of Earth. Even $h_{eff} = h_{em} = h_{gr}$ hypothesis makes sense. $h_{em} = h_{gr}$ is also very natural assumption for ATP synthase which can be regarded as a molecular motor whose rotation velocity appears in the formula for h_{em}.

3. The prediction would be that any charged system connected to Earth by flux tubes generates cyclotron dark photons decaying to bio-photons. Bio-photons in turn induce transitions in biomolecules because the energy range is in visible and UV. Magnetic bodies can control biochemistry via resonant coupling with bio-photons.

Molecular recognition mechanism as basic building brick of primitive immune system

The reconnection of U-shaped magnetic flux tubes emanating from a system makes possible a recognition mechanism involving besides reconnection also resonant interaction via cyclotron radiation which can induced also biochemical transitions of $h_{eff} = h_{gr}$ hypothesis holds true.

1. Molecules have U-shaped flux tube loops with fluxes going in opposite directions. This makes possible also super-conductivity with members of Cooper pair at the parallel flux tubes carrying magnetic fluxes in opposite direction since magnetic fields now stabilize Cooper pairs rather than tend to destroy them.

2. The flux loops associated with systems - call them A and B - can reconnect and this leads to the formation of 2 parallel flux tubes connecting A and B. Stable reconnection suggests that magnetic field strengths must be same at the flux tube pairs associated with A and B. This implies same cyclotron frequencies and resonant interaction. This would define molecular mechanism of recognition and sensing the presence of invader molecules - even conscious directed attention might be involved.

3. Systems with magnetic body could be constantly varying the thicknesses of at least some of their flux tubes and in order to reconnect with the magnetic body of a possible invader. This activity could be behind the evolution of the immune system.

   The question is how the system or its sub-system could stabilize itself so that it would receive signals only from one kind of molecule specified by its cyclotron frequency spectrum.

1. If the flux tubes carry monopole flux (this is possible in TGD framework and requires the flux tube cross section is closed 2-surface), stabilization of the flux tube thickness stabilizes the magnetic field strength. How the stabilization of the thickness of the flux tubes could have been achieved?

   Pollack's negatively charged EZs with dark protons at magnetic flux tubes giving rise to dark nuclei identifiable as dark proton sequences suggests an answer. Maybe the presence of dark proton sequences could stabilize the flux tube thickness. Dark proton sequences have also interpretation as dark DNA/RNA/amino-acid sequences [L3].

   A further question is whether the magnetic body of the prebiotic cell identified as EZ could use the information about invader molecule to represent its magnetic body either concretely and perhaps even symbolically and regenerate the concrete representation when needed.

1. The concrete representation could be in terms of dark proteins whose folding would represent the topology of the invader molecule and symbolic representation in terms of dark DNA transcribed to dark protein. If the dark protein has same topology of knotting it could more easily attach to the invader molecule and make it harmless. Note that the invaders are naturally other dark DNAs and proteins jus as in living matter. The higher purpose behind this cold war would be stimulation of mimicry - emulation in computer science - leading to generation of cognitive representations and negentropic entanglement.

2. Not only the representation of the 3-D magnetic body - its behavior - is possible. In ZEO also the representation of the dynamical evolution of magnetic body becomes possible since basic objects are pairs of 3-surfaces at future and past boundaries of causal diamond. The challenge is to represent the topology time development of magnetic body - 2-braiding, first concretely by mimicking it and then symbolically in terms of DNA coding for proteins doing the mimicry. The obvious representation for the behavior of magnetic body of invader molecule would be in terms of folding and unfolding of protein representing it.

3. The question how the symbolic representation could have emerged leads to a vision about how genetic code emerged. The model for living system as topological quantum computer utilizing 2-braiding for string world sheets at 4-D space-time leads to the idea that 3-D coordinate grids formed by flux tubes are central for TQC: each node of grid is characterized by 6 bits telling about the topology of the node concerning 2-braiding. Could the 6 bits of dark DNA code for the local topology of the invader molecule and an the flux tube complex mimicking it?

4. This raises the possibility that DNA strands - one for each coordinate line in say z-direction could code for the 2-braiding of 3-D coordinate grid and in this manner code for the magnetic template of invader molecule and also that of the biological body. Therefore genetic code would code for both the basic building bricks of the biological body and 4-D magnetic body serving as template for the development of biological body.

One can imagine how the biochemical evolution after this stage might have taken place.

1. At the next step the chemical representation of genetic code would have emerged. Dark proteins learned to attach to real proteins and real proteins to other proteins and DNA and bio-catalysis became possible.

2. The transformation of the ordinary photons emitted in the transitions of biomolecules to dark photons made possible the recognition of invader molecules using ordinary photons emitted in their molecular transitions.

3. Magnetic bodies learned to control biochemical reactions by using dark cyclotron radiation transformed to bio-photons.

4. Gradually dark and ordinary proteins developed a rich repertoire of functions relying on reconnection, communication by dark photons, and attachment in invader molecule. Proteins began to serve as building bricks, as bio-catalysts, promote the replication of DNA, responding to stimuli, serve as receptors.

Possible mechanism of water memory and homeopathy

The general vision about prebiotic evolution described above suggests that the mechanisms of water memory and homeopathy are basically the same as those underlying the workings of the immune system.

1. Exclusion zones could define primordial life forms with genetic code. They are able to detect the presence of invader molecule from its cyclotron frequency spectrum.

2. Dark proteins can form concrete memory representations of the invader molecules in terms of dark proton sequences defining dark proteins. The folding of these dark proteins mimics the behavior of the magnetic bodies of the invaders. These dark proteins can attach to the magnetic body of the invader molecule to make it non-dangerous. Even symbolic representations in terms of dark DNA allowing transcription and translation to concrete dark protein representation could be involved. The procedure involved in the manufacture of homeopathic remedy could be seen as a series of "environmental catastrophes" driving the evolution of dark primordial life by feeding in metabolic energy and generating new EZs, which mimic the invader molecules and existing EZs mimicking them.

3. In organism the dark DNA representing the invader molecule would generate ordinary genes coding for ordinary proteins attaching to the invader molecules by the attachment of ordinary DNA nucleotides to them. The attachment would involve h_{eff} reducing phase transition reducing the length of connecting flux tube.

4. Later dark genetic code transformed to chemical genetic code as dark DNA strands were formed around dark double strands and large number of other biological functions emerged besides immune response.

5. The mechanical agitation in the manufacturing of homeopathic remedy generates exclusion zones and new primitive life forms by providing the needed energy. These in turn recognize and memorize invader molecules and their already existing representations as EZs.

2.9.3 Direct Empirical Evidence For Dark DNA?!

Sciencedaily tells about extremely interesting finding related to DNA (`http://tinyurl.com/pbzqx36`. The finding is just what breakthrough discovery should be: it must be something impossible in the existing world view.

What has been found [I77] (`http://tinyurl.com/y9849jkz`) is that knock-out (removing parts of gene to prevent transcription to mRNA) and knock-down of gene (prevent protein translation) seem to have different consequences. Removing parts of gene need not have the expected effect at the level of proteins! Does this mean that somehow DNA as a whole can compensate the effects caused by knock-out but not those by knock-down? This explanation is natural in the standard conceptual framework and is proposed in the article.

Could this be explained by assuming that genome is a hologram as Gariaev *et al* (`http://tinyurl.com/ycosxzen`) [I53, I8] have first suggested? Also TGD leads to a vision about living system as a conscious hologram [K23]. Small local changes of genes could be compensated. Somehow the entire genome would react like brain to a local brain damage: other regions of brain take the duties of the damaged region. Could the idea about DNA double strand as nano-brain having left and right strands instead of hemispheres"help here. Does DNA indeed act as a macroscopic quantum unit? The problem is that transcription is local rather than holistic process. Something very simple should lurk behind the compensation mechanism.

Could transcription transform dark DNA to dark mRNA?

Also the TGD based notion of dark DNA comes in mind [K53, L3] (`http://tinyurl.com/ybp338x5`, `http://tinyurl.com/yag67j4p`). Dark DNA consists of dark proton sequences for which states of single DNA proton correspond to those of DNA, mRNA, aminoacids, and tRNA. Dark DNA is one of the speculative ideas of TGD inspired quantum biology getting support from Pollack's findings (`http://tinyurl.com/oyhstc2` [L23], [K83]). Ordinary biomolecules would only make their dark counterparts visible: dark biomolecules would serve as a template around which ordinary biomolecules such as DNA strands are formed in TGD Universe. All basic biomolecules of genetics would be pairs of ordinary biomolecule and its dark proton analog.

Although ordinary DNA is knocked out of ordinary gene, dark gene would still exist! If dark DNA actually serves as template for the transcription to mRNA, everything is still ok after knockout! Could it be that we do not understand even transcription correctly? Could it actually occur at the level of dark DNA and mRNA?! Dark mRNA would attach to dark DNA after which ordinary mRNA would attach to the dark mRNA. One step more!

Damaged DNA could still do its job! DNA transcription would would have very little to do with bio-chemistry! If this view about DNA transcription is correct, it would suggest a totally new manner to fix DNA damages. These damages could be actually at the level of dark DNA, and the challenge of dark genetic engineering would be to modify dark DNA to achieve a proper functioning.

Could dark genetics help to understand the non-uniqueness of the genetic code?

Also translation could be based on pairing of dark mRNA and dark tRNA. This suggests a fresh perspective to some strange and even ugly looking features of the genetic code. Are DNA and mRNA always paired with their dark variants? Do also amino-acids and anticodons of tRNA pair in this manner with their dark variants? Could the pairings at dark matter level be universal and determined by the pairing of dark amino-acids with the anticodons of dark RNA? Could the anomalies of the code be reduced to the non-uniqueness of the pairing of dark and ordinary variants of basic bio-molecules (pairings RNA–dark RNA, amino-acid– dark amino-acid, and amino-acid–ordinary amino-acid in tRNA).

1. There are several variants of the genetic code differing slightly from each other: correspondence between DNA/mRNA codons and amino-acids is not always the same. Could dark-dark pairings be universal? Could the variations in dark anticodon - anticodon pairing and dark amino-acid-amino-acid pairing in tRNA molecules explain the variations of the genetic code?

2. For some variants of the genetic code a stop codon can code for amino-acid. The explanation at the level of tRNA seems to be the same as in standard framework. For the standard code

the stop codons do not have tRNA representatives. If stop codon codes for amino-acids, the stop codon has tRNA representation. But how the mRNA knows that the stop codon is indeed stop codon if the tRNA associated with it is present in the same cell?

Could it be that stop codon property is determined already at the level of DNA and mRNA? If the dark variant of genuine stop codon is missing in DNA and therefore also in mRNA the translation stops if it is induced from that at the level of dark mRNA. Could also the splicing of mRNA be due to the splitting of dark DNA and dark mRNA? If so genes would be separated from intronic portions of DNA in that they would pair with dark DNA. Could it be that the intronic regions do not pair with their dark counterparts. They would be specialized to topological quantum computations in the TGD inspired proposal [K5].

Start codon (usually AUG coding met) serves as a Start codon defining the reading frame (there are 3 possible reading frames). Dark DNA would naturally begin from this codon.

3. Also two additional amino-acids Pyl and Sec appear in Nature. Gariaev *et al* have proposed that the genetic code is context dependent so that the meaning of DNA codon is not always the same. This non-universality could be reduced to the non-uniqueness of dark amino-acid– amino-acid pairing in tRNA if genetic code is universal.

Could dark genetics help to understand wobble base pairing?

Wobble base pairing (`http://tinyurl.com/y73se8vs`) is second not-so-well understood phenomenon. In the standard variant of the code there are 61 mRNAs translated to amino-acids. The number of tRNA anticodons (formed by the pairs of amino-acid and RNA molecules) should be also 61 in order to have 1-1 pairing between tRNA and mRNA. The number of ordinary tRNAs is however smaller than 61 in the sense that the number of RNAs associated with them is smaller than 45. tRNA anticodons must be able to pair with several mRNA codons coding for given amino-acid. This is possible since tRNA anticodons can be chosen to be representative for the mRNA codons coding a given amino-acid in such that all mRNA codons coding for the same amino-acid pair with at least one tRNA anticodon.

1. This looks somewhat confusing but is actually very simple: genetic code can be seen as a composite of two codes: first 64 DNAs/mRNAs to are coded to $N < 45$ anticodons in tRNA, and then these N anticodons are coded to 20 amino-acids. One must select N anticodon representatives for the mRNAs in the 20 sets of mRNA codons coding for a given amino-acid such that each amino-acid has at least one anticodon representative. A large number of choices is possible and the wobble hypothesis of Crick pose reduce the number of options.

2. The wobble hypothesis of Crick states that the nucleotide in the third codon position of RNA codon of tRNA has the needed non-unique base pairing: this is clear from the high symmetries of the third basis. There is exact U-C symmetry and approximate A-G symmetry with respect to the third basis of RNA codon (note that the conjugates of RNA codons are obtained by A↔U and C↔G permutations).

3. The first two basis in the codon pair in 1-1 manner to the second and third basis of anticodon. The third basis of anticodon corresponds to the third letter of mRNA codon. If it is A or C the correspondence is assumed to be 1-to-1: this gives 32 tRNAs. If the first basis of anticodon is G or U the 2 mRNA basis can pair with it: they would be naturally A for G and C for U by symmetry. One would select A from A-G doublet and C from U-C double. This would give 16 anticodons: 48 anticodons altogether, which is however larger than 45. Furthermore, this would not give quite the correct code since A-G symmetry is not exact.

Smaller number of tRNAs is however enough since the code has almost symmetry also with respect to A and C exchange not yet utilized. The trick is to replace in some cases the first basis of anticodon with Inosine I, which pairs with 3 mRNA basis. This replacement is possible only for those amino-acids for which the number of RNAs coding the amino-acid is 3 or larger (the amino-acids coded by 4 or 6 codons).

4. It can be shown at least 32 different tRNAs are needed to realize genetic code by using wobble base pairing. Full A-C and G-U symmetry for the third basis of codon would give 16+16=32 codons. One can ask whether tRNA somehow realizes this full symmetry?

How dark variants of could help to understand wobble base pairing? Suppose for a moment that the visible genetics be a shadow of the dark one and fails to represent it completely. Suppose the pairing of ordinary and dark variants of tRNA anticodons *resp.* amino-acids and that translation proceeds at the level of dark mRNA, dark anticodons, and dark amino-acids, and is made visible by its bio-chemical shadow. Could this allow to gain insights about wobble base pairing? Could the peculiarities of tRNA serve for some other - essentially bio-chemical - purposes?

The basic idea would be simple: chemistry does not determine the pairing but it occurs at the level of the dark mRNA codons and dark tRNA anticodons. There would be no need to reduce wobble phenomenon to biochemistry and the only assumption needed would be that chemistry does not prevent the natural dark pairing producing standard genetic code apart from the modifications implied by non-standard dark amino-acid–amino-acid pairing explaining for different codes and the possibility that stop codon can in some situation pair with dark mRNA.

One can consider two options.

1. The number of dark RNAs is 64 and the pairings between dark mRNA and dark anticodons and dark anticodons and dark amino-acids are 1-to-1 and only the pairing between dark RNA codons and anticodons in tRNA is many-to-1.

2. The model of dark genetic code [K53] suggests that there are 40 dark proton states, which could serve as dark analogs of tRNA. This number is larger than 32 needed to realize the genetic code as a composite code. I have cautiously suggested that the proposed universal code could map dark mRNA states of the same total spin (there is breaking of rotational symmetry to that around the axis of dark proton sequences) to dark tRNA/dark amino-acid states with the same total spin projection. The geometric realization would in terms of color flux tubes connecting the dark protons of corresponding dark proton sequences. Also in ordinary nuclei the nucleons are proposed to be connected by color flux tubes so that they form nuclear strings [L3] and dark proton sequences would be essentially dark variants of nuclei.

One should understand the details of the dark mRNA–tRNA anticodon correspondence. One can also ask whether the dark genetic code and the code deduced from the icosahedral model for music harmony [K91] [L19] are mutually consistent. This model implies the decomposition of 60+4 DNA codons to 20+20+20+4 codons, where each "20" corresponds to one particular icosahedral Hamilton's cycle with characteristic icosahedral symmetries. "4" can be assigned to tetrahedron regarded either disjoint from icosahedron or glued to it along one of its faces. This allows to understand both the standard code and the code with two stop codons in which exotic amino-acids Pyl and Sec appear. One should understand the compositeness $64 \rightarrow 40 \rightarrow 20$ of the dark genetic code and and whether it relates to the icosatetrahedral realization of the code.

I have proposed [K58] (`http://tinyurl.com/ycm48w54`) that dark variants of transcription, translation, etc.. can occur and make possible kind of R&D laboratory so that organisms can test the consequences of variations of DNA. If ordinary translation and transcription are induced from their dark variants it would not be surprising and if dark biomolecules could also appear as unpaired variants, these processes could occur as purely dark variants. Organisms could indeed do experimentation in the virtual world model of biology and pairing with ordinary bio-molecules would make things real.

There is now evidence for this picture. It has been discovered [J55] (`http://tinyurl.com/oec3mff`) that brain cells have a mosaic like distribution of genomes (`http://tinyurl.com/odwajdq`) . In standard framework this mosaic should be created by random mutations. The mechanism of mutation is reported to involve transcription rather than DNA replication. The mutation would take place for DNA when its is copied to RNA after opening of the DNA double strand. The mutations would have occurred during the period when neurons replicate and the mutation history can be read by studying the distributions of changes in the genome.

This brings in mind the finding that removing a part of gene does not affect transcription. In both cases it is dark DNA, which would serve as a template for transcription rather than ordinary DNA. This suggests that the dark DNA is not changed in these modifications and mRNA is determined by the dark DNA, which would serve as a template for transcription rather than ordinary DNA. If this were the case also for neurons, the mutations of neuronal genes should not

affect the gene transcription at all, and there would be no negative (or positive) effects on brain function. This seems too conservative. The mutations should have some more active role.

One can consider also different interpretation. The mutations of DNA could be induced by the dark DNA. As dark DNA changes, ordinary DNA associated with it is forced to change too - sooner or later. Especially so when the genome is in a state in which mutations can take place easily. Neurons during to replication stage could have such quantum critical genomes.

Evolution would not be mere selection by a survival of random mutations by external environment in the time scale much longer than lifetime of individual - but a controlled process, which can occur in time scale shorter than lifetime and differently inside parts of say brain. This is what the idea TGD inspired biology suggests. The modified DNA could be dark DNA and and serve as template for transcription and also induce transformation of ordinary DNA associated with it.

Whether this change can be transferred to the germ cells to be transferred to the offspring remains of course an open question. For instance, one can imagine that dark DNA strands (magnetic flux tubes) can penetrate germ cell membranes and replace the earlier dark DNA sections and induce change of ordinary DNA. Or is a more delicate mechanism involving dark photons in question. With inspiration coming from the findings reported by Peter Gariaev [I53] I have proposed a model of remote DNA replication suggesting that DNA can be replicated remotely if the needed nucleotides are present [K127]: the information about DNA could be transferred as dark photons, which can be transformed to ordinary photons identified as bio-photons. Could Lysenko have been at least partially right despite that he was a swindler basing his views on ideology?

In any case, TGD inspired biology allows to imagine a controlled evolution of DNA in analogy to that what occurs in R&D departments of modern technological organizations. The notion of dark DNA suggests that biological systems indeed have a "R&D department" in which new variants of DNA studied as "dark DNA" sequences realised as dark proton sequences - same about dark RNA, and amino-acids and even tRNA. The possibility to transcribe RNA from dark DNA would mean that the testing can be carried in real life situations.

There indeed exists evidence that traumatic - and thus highly emotional - memories may be passed down through generations in genome [J23] (`http://tinyurl.com/oja8v94`). Could the modifications of brain DNA represent long term memories as the above described experiment suggests? Could the memories be transferred to the germ cells using the mechanism sketched above?

2.9.4   Is Replication Of Magnetic Body Behind Biological Replication?

The vision about exclusion zone (EZ) like regions as primordial life forms and facts about water memory and homeopathy lead to a vision about how primitive immune system might have developed and how the recent genetic code might have emerged.

Magnetic body and dark analogs of bio-polymers should still play key role in living matter. The basic idea is that the time evolution of the magnetic body is the template for the time evolution of the biological body. In [K88] [L21] various pieces of evidence for the role of magnetic body as "morphogenetic field" are discussed. For instance, the replication of DNA and cell would reduce basically to that for corresponding magnetic bodies.

Replication of magnetic body is analogous to what happens in 3-vertex of Feynman diagram. This occurs in several scales. This would make possible dark DNA (dDNA) replication and copying of dDNA to dDNA+dRNA as well as copying of dRNA to dRNA+dark protein.

Replication process should start from the higher levels of dark matter hierarchy and proceed to shorter scales. The basic constraint from ZEO is that the time evolutions of magnetic bodies at various levels of the hierarchy are highly unique as preferred extremals connecting initial and final 3-surfaces. For the maxima of vacuum functional only preferred pairs of 3-surfaces are possible. This gives rise to what might be called "standard behaviors". Also the replication would be this kind of behavioral pattern. In the context of the positive energy ontology it is extremely difficult to understand why the predictability of cell replication or the development of organism from single cell by repeated cell divisions.

Remote gene replication [K127] might be one application: the model described was actually developed before the idea that the replication of the magnetic body could be the fundamental mechanism. Its reversal could be basic mechanism of bio-catalysis and induce the attachment of

bio-molecules together. Also ordinary DNA replication could be induced by the same electromagnetic signal as remote replication.

The sketch about replication of DNA would look roughly like following.

1. Assume that the portion of DNA promoting DNA replication is activated by dark radiation at some frequency and that the promoter region emits radiation with same frequency. This activates further promoter regions -also in other cell nuclei. The replication process is amplified exponentially. The negative feedback is necessary in the general case and is provided by attachment of the produced proteins (basically dark proteins) to the genes making them inactive.

2. This might occur during cell division which might involve irradiation by dark analog of white noise exciting all promoter regions. Certainly the coherence of this process is essential and here the higher levels of the dark matter hierarchy would be essential.

3. Remote replication becomes possible if the dark radiation exciting promoter region can leak to other cells or even other organisms. Large h_{eff} might make this possible.

4. Also remote transcription is possible by the same mechanism. Actually remote variants of very many basic processes seem to be possible.

5. The observations of Peter Gariaev's group about effects of laser light on genes [I55, I95] support this view as also the findings of group of HIV Nobelist Montagnier [I65, I66].

2.9.5 Quantum Model For Metabolism

First it is good to list some basic facts about energy metabolism.

1. ADP$\rightarrow$ ATP meaning the addition of phosphate to ADP is believed to be the fundamental step of metabolism. The process occurs when protons flow through the ATP synthase, which can be regarded as a nano-motor with a rotating shaft. During single turn three ADPs are phosphorylated and 3 protons flow through the "turbine" of the nano-motor and give up their Coulombic and chemical energy parameterized in terms of chemical potential difference. There is clearly a strong analogy with power plant. High energy phosphate bond is believed to receive the metabolic energy transferred from the flow of protons through the mitochondrial membrane.

2. The nominal value of metabolic energy quantum about.5 eV. The Coulomb energy associated with the mitochondrial membrane is 50-80 meV and by almost order of magnitude too small. The large chemical potential difference is believed to explain the large metabolic energy gain. This requires that the process is regarded as purely thermodynamical. This is a questionable assumption even in standard physics context and does not conform with the TGD based idea that transmembrane proteins such as ATP synthase act as large h_{eff} Josephson junctions. The square root of thermodynamics forced by zero energy ontology suggests itself as a proper description of cell membrane as macroscopically quantum coherent system.

3. The notion of high energy phosphate bond is not well understood. The storage of energy dark cyclotron energy at the magnetic body of phosphate suggests itself as TGD based description.

How to understand the value of $heff$?

The basis problem is to understand how h_{eff} depends on the parameters characterizing the situation at the magnetic flux tube connecting two systems. I have considered several mechanisms for the generation of large h_{eff} phase.

1. The model for h_{eff} in systems involving charge separation stimulated by AC current was based on the identification of Josephson frequency with the frequency of AC current: $f_J = E_J/h_{eff} = f_{AC}$ predicting $h_{eff}/h = E_J/hf_{AC}$ [L14].

   The findings of Pollack and the difficulties to understand metabolic energy quantum of nominal value.5 eV in the simplest model for cell membrane as Josephson junction as Josephson

energy for Cooper pair equalto to $ZeV = 10 - 10.6$ mV inspired the assumption that cyclotron energies at flux tubes traversing cell membrane can be different at the two sides of the cell membrane [K44, K90]. This would lead to a generalization of the notion of Josephson junction associated with the transmembrane protein and generalizes $f_J = f_{AC}$ to $\Delta f_c + f_J = f_A C$ predicting $h_{eff}/h = E_J/(h(\Delta f_c - f_{AC})$ so that h_{eff}/h would get arbitrarily large values near resonance $f_{AC} = f_C$. Note that correct sign requires $\Delta f_C - f_{AC} > 0$.

2. The conjecture $\hbar_{eff} = \hbar_{gr} = GMm/v_0$ could make sense at microscopic level for particle-Earth pair and would predict a universal spectrum of bio-photons if identified as resulting from the decays of dark cyclotron photons to bio-photons. The first guess for the parameter v_0 would be as a rotational velocity associated with the two systems such as Earth and electron rotating with it. In case of planetary orbits $v = v_0$ is not consistent with

$$\frac{v}{c} = \frac{\sqrt{\frac{v_0}{c}}}{4\pi n}$$

following from Bohr rules in $1/r$ potential (n denotes the principal quantum number).

3. $h_{eff} = h_{em} = Z_1 Z_2 e^2/v_0$ hypothesis is a natural looking generalization in systems involve large charge separations, say the exclusion zones discovered by Pollack providing a model for prebiotic life forms. The philosophy would be that when the coupling strength between systems becomes so large that perturbation theory fails, the value of h_{eff} increases and makes perturbation theory is in powers of $1/h_{eff}$) possible again. At space-time level this means emergence of non-determinism so that 3-surfaces at the future and past boundaries of causal diamond are connected by n-branched space-time surface for which branches fuse at the two ends. Dark matter would be Nature's manner to define what non-perturbative phases are. The strong hypothesis $h_{eff} = h_{em} = h_{gr}$ might make possible reconnection between em and gravimagnetic flux tubes and ATP synthase is here a candidate system.

4. Rotating magnetic systems with high negative charge are also good candidates for generating large h_{eff} at the magnetic flux tubes possibly contain dark proton sequences identifiable as dark nuclei. I have also proposed that a system subject to constant torque allowing description in terms of potential function which is multivalued as function of the angle coordinate ϕ leads rather naturally to generation of large h_{eff} [K58] when one requires internal consistency.

How metabolic energy is transferred?

The basic question concerns the mechanism of energy transfer from nutrients. It should be however emphasized that the transfer might not be the really important aspect. The transfer of negentropic entanglement from nutrient to the organism might be of equal importance.

1. Zero energy ontology (ZEO) suggests that magnetic bodies are carriers of the metabolic energy. What does this mean is not quite clear but cyclotron energies or ions or Cooper pairs of them proportional to h_{eff} are obvious candidates concerning energy storage. The value of $h_{eff} \simeq 10^{14}$ guaranteeing the energies of dark EEG photons are in the range of bio-photon energies would mean that storage as cyclotron energies is very effective and the liberated energy quanta can directly induce molecular transitions essential for bio-chemical reactions.

2. The liberation of metabolic energy could take place in a phase transition in which p-adic length scale increases and h_{eff} is reduced in such a way that the length of flux tubes is not changed. This induces a coherent quantum transition in the sense that large number of particles can liberate cyclotron energy as cyclotron energy scale is reduced in the reduction of magnetic field strength. As protons flow from thinner flux tube with smaller h_{eff} to thicker one, similar reduction of cyclotron energy takes place and the energy is liberated, and would be received by ATP synthase to form ATP from ADP. This mechanism could be universal and at work also in other situations.

3. At quantitative level the identification $h_{eff} = h_{gr}$ of gravitational Planck constant with $h_{eff} = n \times h$ at microscopic level at least is an attractive hypothesis [K109, K90]. Gravitational Planck constant can be expressed as $\hbar_{gr} = GMm/v_0$, where v_0 is taken to be the

rotational velocity of Earth. Assuming this for Cooper pairs of rotating super-conductor explains the gravimagnetic anomaly claimed by Tajmar et al [E7, E9]. It also predicts a universal energy spectrum of dark cyclotron photons in the range of bio-photon energies and gives thus support for the hypothesis that dark EEG photons decay to bio-photons. The metabolic energy quantum for proton of order .5 eV is consistent with the identification as cyclotron energy difference for proton over mitochondrial membrane. The hypothesis $h_{em} = h_{eff} = h_{gr}$ makes also sense for the nano-motor defined by ATP synthase transforming ADP to ATP. The interpretation would be that this condition makes possible the reconnection of electromagnetic and gravitational flux tubes.

One can imagine also different scenario involving phase transition changing the value of h_{eff} assignable to atoms. TGD indeed predicts also small values of h_{eff}. $h_{eff} = h_{em}$ would hold true when em interaction becomes non-perturbative. In this case NE would be short ranged and associated with atomic/molecular systems with nonstandard value of h_{eff}.

1. For dark atoms the scale of binding energy behaves like $1/h_{eff}^2$ and is thus reduced for dark atoms [K37, K38, K39, K40]. The creation of dark atoms would require metabolic energy. This metabolic energy could also be liberated as dark atoms transforms to ordinary atom. Metabolic electrons could be associated with dark atoms and also the dark atoms in nutrients could provide metabolic energy driving protons through the mitochondrial membrane against potential gradient and transforming ADP to ATP contains high energy phosphate bond, which would actually correspond to the presence of dark (say hydrogen -) atom. Phosphate containing the dark atom would carry the negentropic entanglement or be accompanied by dark magnetic flux tube.

2. Phosphorylation and de-phosphorylation could be interpreted in terms of reconnection of flux tubes so that the dark proton associated with phosphate is transferred to the acceptor molecule. I have proposed that the deeper meaning of metabolism is transfer of negentropic entanglement (NE). The reconnection of flux tubes would transfer NE between ATP and third party to NE between acceptor molecule and third party. There is a large number of alternative identifications for NE. It could be short range entanglement associated with $h_{eff} = h_{em}$ assignable to electron and nucleus of dark atoms, to pairs of atoms or molecules, or very long range entanglement between molecule and large scale structure with size scale of Earth or even galaxy and associated with $h_{eff} = h_{gr}$. Both forms of NE might be involved and distinguish between two evolutionary levels.

3. Short ranged NE could be associated with dark atoms for which the scale of binding energy behaves like $1/h_{eff}^2$ and is thus reduced for dark atoms [K37, K38, K39, K40]. The creation of dark atoms would require metabolic energy. This metabolic energy could also be liberated as dark atoms transforms to ordinary atom. The dark atoms in nutrients transforming to ordinary atoms could provide the metabolic energy driving protons through the mitochondrial membrane against potential gradient and transforming ADP to ATP contains high energy phosphate bond, which would actually correspond to the presence of dark (say hydrogen -) atom. Phosphate containing the dark atom would carry the NE or be accompanied by dark magnetic flux tube. The transfer of NE would mean its disappearance followed by reappearance and it could happen that $h_{eff}/h = n$ is reduced in the process.

4. The simplest view about photosynthesis would be that the absorption of solar photons excites some atoms to dark states and that nutrients contain these dark atoms as stable enough entities. The contamination of nutrients could mean the decay of these dark atoms to the normal states.

Exclusion zones as prebiotic cells

TGD based model model [L23], [K86] for Pollack's findings [L23] provides further guidelines.

1. Pollack *et al* discovered what they call exclusion zones and fourth gel like phase of water. The phenomenon occurs when water is bounded by gel and is irradiated with say visible light. Exclusion zones are negatively charged regions of water with positively charged environment.

They act like batteries and have rather exotic properties. For instance, various impurities are repelled from exclusion zone.

2. The observed $H_{1.5}O$ stoichiometry implies that every fourth proton or hydrogen atom is dark and is transferred to the region outside the negatively charged exclusion zone. If only protons are transferred, very high negative charge density is generated. The size of the exclusion zone varies up to 100 μm and is in the range of cell sizes.

3. Dark matter corresponds in TGD Universe to phases with nonstandard value of Planck constant: $h_{eff} = n \times h$ phases at the "magnetic body" of the system (negatively charged region now). Magnetic body corresponds in Maxwell's theory to the magnetic fields generated by the system. Magnetic body consists of flux quanta (flux tubes and sheets).

4. If dark protons with say size scale of atomic size reside at flux tubes, one can assume that they form strings giving rise to dark atomic nuclei. Also ordinary nuclei consist of strings of dark protons and strings of neutrons. Various impurities are transferred from exclusion zone to the exterior suggesting that they become dark particles at magnetic flux tubes.

5. The quantum states of dark protons consist of 3 quarks and a simple model involving rotational symmetry around the axis of dark proton string predicts that the states of dark proton can be arranged into groups which correspond to DNA, RNA, amino-acids and possibly also tRNA molecules. Vertebrate genetic code can be realized as a natural correspondence between DNA/ RNA and amino-acids [L3, K53].

6. Negatively charged EZ could define a pre-biotic cell so that water would be a primitive pre-biotic life form. The voltage would be the analog of the resting potential. The transformation of dark protons to ordinary ones would liberate metabolic energy so that primitive metabolism and photosynthesis would be realized. One can also consider a more general possibility that cyclotron energies are different at flux tube portions in the interior and exterior of the EZ analogous to cell membrane. This would increase the value of the metabolic energy currency by adding to Josephson energy ZeV the difference of dark cyclotron energies proportional to h_{eff}. One expects that dark counterparts of basic bio-polymers are still present in living matter and play a fundamental role.

What might happen in ADP$\rightarrow$ ATP process?

The identification of the exclusion zone with magnetic body as a basic structure allows to speculate about what might happen in ADP $\rightarrow$ ATP process and how ATP might store metabolic energy.

1. The strings of dark protons [K53] would be analogous to basic bio-polymers serving as the basic fuel of metabolics hydrolysed in metabolism. Basic biopolymers tend to be negatively charged and could therefore be accompanied by dark proton strings and the liberated metabolic energy might be stored by these strings as cyclotron energy and as Coulomb energy.

2. The simplest guess is that metabolism has developed from the transformation of dark protons to ordinary ones as the analog of EZ transforms back to ordinary water and potential potential difference disappears. One cana also consider generalizations of this picture. A phase transition reducing h_{eff} and increasing p-adic scale such that the size scale of the flux tube remains fixed but cyclotron energy is reduced. This phase transition could also effectively accompany the flow of protons through the boundary of EZ if h_{eff} is smaller and p-adic scale longer at the other side. This mechanism could be stilla at work at the level of mitochondria for dark protons.

3. The notion of high energy phosphate bond is somewhat mysterious. ATP is negatively charged and one can wonder whether it could be accompanied by EZ assignable to the negatively charged phosphates. Also DNA strands and many other biomolecules carry negative charge due to the phosphates. Could the metabolic energy be stored to the magneti body of ATP or of phosphate and eventually liberated by flow of protons to flux tubes with weaker magnetic field?

One can ask why the rotation of ATP synthase motor is necessary. Could the centrifugal acceleration drive dark particles to the magnetic body or keep them there thus stabilizing the dark phase? The dark protons at the magnetic body rotating with the system would remain to magnetic body and would avoid transition to ordinary protons if it is induced by the vicinity of ordinary protons serving as seeds for phase transition. If this interpretation is in the right direction, the rotating magnetic systems might provide a way to create dark matter [K15].

Energy metabolism as transfer of negentropic entanglement?

Negentropic entanglement (NE, see **Fig. http://tgdtheory.fi/appfigures/cat.jpg** or **Fig. ??** in the appendix of this book) is 2-particle property (or more generally $n > 1$-particle property). One can argue that this is not consistent with the naïve idea about systems carrying NE as a resource analogous to metabolic energy. If negentropy transfer is behind metabolism and if one accepts this objection, one must ask whether metabolism actually corresponds to a transfer of NE between nutrient A and some fixed system B so that NE transforms to that between receiver R and same fixed system B? If so, could this could B correspond some higher collective level of consciousness perhaps identifiable as gravitational Mother Gaia (MG) as suggested by the success of $h_{gr} = h_{eff}$ hypothesis at microscopic level?

1. Negentropic entanglement (NE) would be transferred. Nutrients would be negentropically entangled with something very crucial for life. MG is a good candidate in this respect. Even Sun can be considered. Gravitational NE with MG would make possible dark EEG, etc... Basic formula is $\hbar_{gr} = GMm/v_0$, v_0 the rotational velocity at surface at the surface of Earth.

2. Formula generalizes to em case: $h_{em} = Z_1 Z_2 e^2 / v_0$ and would apply to ATP synthase being consistent with $h_{gr} = h_{em} = h_{eff}$. Em flux tubes could reconnect with gravitational flux tubes for $h_{gr} = h_{em}$.

3. Nutrient-MG NE can be transformed to molecule-MG NE by the sequence N-MG → P-MG → ATP-MG → R-MG (N for nutrient, R for receiver).

4. The basic mechanism would be the reconnection of magnetic U-shaped loops associated with various molecules serving as kind of tentacles: N/P/ADP/R would have this kind of loops.

One can represent a critical comment. The notion of personal magnetic body (PMB) controlling biological body (BB) is central for TGD inspired theory of consciousness. The above argument does not involve it at all. Can the notion of PMB be therefore consistent with MG hypothesis? Or is PMB in some sense part of the magnetic body of MG - say in the sense that the flux tubes of PMB could be inside flux tubes of MG? Mystics would perhaps equate MG with PMB but this leads to paradoxes.

1. An attractive guess is that $h_{em} = h_{gr}$ holds true for PMB so that it can interact with MG by forming reconnections. Nutrients are dead but have NE with MG so that metabolism allows BB to have NE with MG.

2. How PMB could generate NE with BB? Could it reconnect with the flux tube pairs connecting MG with BB? Do both MG and PMB have NE with BB during life-time. What happens in biological death?: does the NE between PMB and BB transform to that between BB and MG again and only the NE between PMB and MG remains? This would conform with what spiritual teachings say.

3. If the answers to these questions are "yes", the basic purpose of metabolism would be the transformation of gravitational NE between MG and nutrients to that between MG and biomolecules. Magnetic bodies would "steal" part of this NE by reconnecting between MG and BB to that between PMB and BB: note that this process would be something new besides molecular metabolism and could be interpreted as a higher level metabolism. All this would be basically transfer of information from collective level of consciousness to lower levels to be processed and further enriched and to be returned back to MG in biological death: nothing would lost! Biological death itself would be reconnection transforming flux tube bonds to PMB to bonds to MG.

Could electrons serve as nutrients?

The New Scientist article (see `http://tinyurl.com/ybd4g2kl`) about bacteria using electrons as nutrients is very interesting reading since the reported phenomenon might serve as a test for the TGD inspired idea about metabolism as a transfer of negentropic entanglement (NE, see **Fig.** `http://tgdtheory.fi/appfigures/cat.jpg` or **Fig. ??** in the appendix of this book) at fundamental level discussed in [K90] (see `http://tinyurl.com/yat9bx9j`).

1. NE is always between two systems: nutrient and something, call it X. The proposal inspired by a numerical coincidence was that X could be what I have called Mother Gaia. X could be also something else, say personal magnetic body. The starting point was the claim that the anomalously high mass of electronic Cooper pair in rotating supercounductor (slightly larger than the sum of electron masses!) could be due to a gravimagnetic effects which is however too strong by a factor 10^{28}. This claim was made by a respected group of scientists. Since the effect is proportional to the gravimagnetic Thomson field proportional to the square of Planck constant, the obvious TGD inspired explanation would be $h_{eff} \simeq 10^{14}$ (see `http://tinyurl.com/yb7rsct5` and `http://tinyurl.com/yat9bx9`).

2. Gravitational Planck constant $\hbar_{gr} = GMm/v_0$, v_0 typical velocity in system consisting of masses $M >> m$ and m was introduced originally by Nottale and I proposed that it is genuine Planck constant assignable to flux tubes mediating gravitational interaction between M and m. In the recent case v_0 could be the rotating velocity of Earth around its axis at the surface of Earth.

3. For electron, ions, molecules, .. the value of h_{gr} would of the order of 10^{14} required by the gravimagnetic anomaly and is also of the same order as $h_{eff} = n \times h$ needed by the hypothesis that cyclotron energies for these particles are universal (no mass dependence) and in the visible and UV range assigned to biophotons. Biophotons would result from dark photons via phase transition. This leads to the hypothesis $h_{eff} = h_{gr}$ unifying the two proposals for the hierarchy of Planck constants at least in microscopic scales.

    Thanks to Equivalence Principle implying that gravitational Compton length does not depend on particle's mass, Nottale's findings can be understood if h_{gr} hypothesis holds true only in microscopic scales. This would mean that gravitation in planetery system is mediated by flux tubes attached to particles. One non-trivial implication is that graviton radiation is dark so that single graviton carries much larger energy than in GRT based theory. The decay of dark gravitons to ordinary gravitons would produce bunches of ordinary gravitons rather than continuous stream: maybe this could serve as an experimental signature. Gravitational radiation from pulsars is just at the verge of detection if it is what GRT predicts. TGD would predict pulsed character and this might prevent its identification if based on GRT based belief system.

4. In the recent case the model would say that the electrons serving as nutrients have this kind of negentropic entanglement with Mother Gaia. $h_{gr} = h_{eff}$ would be of order 10^8. Also in nutrients electrons would be the negentropically entangled entities. If the model is correct, nutrient electrons would be dark and could also form Cooper pairs. This might serve as the eventual test.

This is not the only model that one can imagine. TGD predicts also small values of h_{eff}. $h_{eff} = h_{em}$ would hold true when em interaction becomes non-perturbative. In this case NE would be short ranged and associated with atomic/molecular systems. At this moment one cannot exclude the possibility that only short range NE is involved with living matter.

Short ranged NE could be associated with dark atoms for which the scale of binding energy behaves like $1/h_{eff}^2$ and is thus reduced for dark atoms [K37, K38, K39, K40]. The creation of dark atoms would require metabolic energy. This metabolic energy could also be liberated as dark atoms transforms to ordinary atom. Metabolic electrons could be associated with dark atoms and also the dark atoms in nutrients could provide metabolic energy driving protons through the mitochondrial membrane against potential gradient and transforming ADP to ATP contains high energy phosphate bond, which would actually correspond to the presence of dark (say hydrogen

-) atom. Phosphate containing the dark atom would carry the negentropic entanglement or be accompanied by dark magnetic flux tube.

Electrons are certainly fundamental for living matter in TGD Universe.

1. Cell membrane is high T_c electronic super-conductor [K90]. Members of Cooper pairs are at flux tubes carrying opposite magnetic fields so that the magnetic interaction energy produces very large binding energy for the large values of h_{eff} involved: of the order of electron volts! This is also the TGD based general mechanism of high T_c superconductivity: it is now accepted that anti ferromagnetism is crucial and flux tubes carrying fluxes at opposite directions is indeed very antiferromagnetic kind of thing.

2. Josephson energy is proportional to membrane voltage ($E_J = 2eV$) is just above the thermal energy at room temperature meaning minimal metabolic costs.

3. Electron's secondary p-adic time scale is.1 seconds, the fundamental biorhythm which corresponds to 10 Hz alpha resonance.

2.9.6   Humble Origins Of DNA As Nutrient - Really Humble?

I received an interesting link (`http://tinyurl.com/ybv8xu9uDNA_May_Have_Had_Humble_Beginnings_As_Nutrient_Carrier_999.html`) about the indications that DNA may have had rather humble beginnings: it would have served as a nutrient carrier [I81]. Each nucleotide in the phosphate-deoxiribose backbone corresponds to a phosphate and nutrient refers to phosphate assumed to carry metabolic energy in high energy phosphate bond.

In AXP, X=M, D, T the number of phosphates is 1, 2, 3. When ATP transforms to ADP, it gives away one phosphate to the acceptor molecule which receives thus metabolic energy. For DNA there is one phosphate per nucleotide and besides A also T, G, and C are possible.

The attribute "humble" reflects of course the recent view about the role of nutrients and metabolic energy. It is just ordered energy what they are carrying. TGD view about life suggest that "humble" is quite too humble an attribute.

1. The basic notion is potentially conscious information. This is realized as negentropic entanglement for which entanglement probabilities must be rational numbers (or possibly also algebraic numbers in some algebraic extension of rationals) so that their p-adic norms make sense. The entanglement entropy associated with the density matrix characterizing entanglement is defined by a modification of Shannon formula by replacing the probabilities in the argument of the logarithm with their p-adic norms and finding the prime for which the entropy is smallest. The entanglement entropy defined in this manner can be and is negative unlike the usual Shannon entropy. The interpretation is as information associated with entanglement. Second law is not violated since the information is 2-particle property whereas as Shannon entropy is single particle property characterizing average particle.

    The interpretation of negentropic entanglement is as potentially conscious information: the superposition of pairs of states would represent abstraction or rule whose instances would be the pairs of states. The large the number of pairs, the higher the abstraction level.

2. The consistency with standard quantum measurement theory gives strong constraints on the form of the negentropic entanglement. The key notion is that if density matrix is proportional to unit matrix, standard measurement theory says nothing about the outcome of measurement and entanglement can be preserved. Otherwise the reduction occurs to one of the states involved. This situation could correspond to negentropic 2-particle entanglement. For several subsystems each subsystem-complement pair would have similar density matrix. There is also a connection with dark matter identified as phases with non-standard value $h_{eff} = n \times h$ of Planck constant. n defines the dimension of the density matrix. Thus dark matter at magnetic flux quanta would make living matter living.

    In 2-particle case the entanglement coefficients form a unitary matrix typically involved with quantum computing systems. DNA-cell membrane system is indeed assumed to form a topological quantum computer in TGD framework. The braiding of magnetic flux tubes connecting nucleotides with lipids of the cell membrane defines topological quantum computer

program and its time evolution is induced by the flow of lipids forming a 2-D liquid crystal. This flow can be induced by nearby events and also by nerve pulses.

Side-step: Actually pairs of flux tubes are involved to make high temperature super-conductivity possible with members of Cooper pairs at flux tubes with same or opposite directions of spins depending on the direction of magnetic field and thus in spin $S = 0$ or $S = 1$ state. For large value of Planck constant $h_{eff} = n \times h$ the spin-spin interaction energy is large and could correspond in living matter to energies of visible light.

3. Negentropy Maximization Principle (NMP, [K70]) is the basic variational principle of TGD inspired theory of consciousness. NMP states that the gain of negentropic entanglement is maximal in state function reduction so that negentropic entanglement can be stable.

4. NMP guarantees that during evolution by quantum jumps recreating the Universe (and sub-Universes assignable to causal diamonds (CDs)) the information resources of Universe increase. Just to irritate skeptics and also to give respect for the ancient thinkers I have spoken about "Akashic records". Akashic records can be said to form books in a universal library and could be read by interaction free quantum measurement preserving entanglement but generating secondary state function reductions providing conscious information about Akashic records defining also a model of self.

Side-step: Self can be identified as a sequence of state function for which only first quantum is non-trivial at second boundary of CD whereas other quantum jumps induce change of superposition of CDs at the opposite boundary and states at them). Essentially a discretized counterpart of unitary time development would be in question. This allows to understand how the arrow of psychological time emerges and why the contents of sensory experience is about so narrow a time interval. Act of free will corresponds to the first state function reduction at opposite boundary and thus involves change of the arrow of psychological time at some level of self hierarchy: this prediction is consistent with the Libet's findings that conscious decision implies neural activity initiated before the decision ("before" with respect to geometric time, not subjective time).

In this framework the phosphates could be seen as ends of magnetic flux tubes connecting DNA to cell membrane and mediating negentropic entanglement with the cell membrane. DNA as topological quantum computer vision conforms with the interpretation DNA-cell membrane system as "Akaschic records". This role of DNA-cell membrane system would have emerged already before the metabolic machinery, whose function would be to transfer the entanglement of nutrient molecules with some bigger system X to that between biomolecules and X. Some intriguing numerical coincidences suggest that X could be gravitational Mother Gaia and flux tubes mediating gravitational interaction with nutrient molecules and gravitational Mother Gaia could be in question [K83]. This brings in mind Penrose's proposal about the role of quantum gravity. TGD is indeed a theory of quantum gravity predicting that gravitation is quantal in astroscopic length scales.

2.10   More Precise View About Remote DNA Replication

Both Luc Montagnier [I65, I66] and Peter Gariaev [I88] have found strong evidence for what might be called remote replication of DNA. I have developed a TGD inspired model for remote replication using the data from Peter Gariaev [K127], who has developed the notion of wave DNA [I53] supported by Montagnier's findings.

Polymer chain reaction (PCR) [I23] provides a way to build copies of piece of DNA serving as template. Once single copy is produced, it serves as a template for a further copy so that exponential amplification is achieved. Montagnier's and Gariaev's works suggest however that the synthesis of DNA could also occur without a real matrix DNA as remote replication. According to the proposal of Gariaev [I53, I124] DNA template would be remotely represented as what he calls wave DNA. Montagnier [I66] uses 7 Hz ELF radiation to obtain the effect whereas Gariaev [I88] uses scattering of laser light into large interval of frequencies to achieve the effect.

In TGD approach magnetic body containing dark matter with large Planck constant, the associated cyclotron radiation for which energy scale is proportional to effective Planck constant

$h_{eff} = n \times h$ having large values implying conjectured macroscopic quantum coherence of living matter, dark analog of DNA represented as dark proton sequences at magnetic flux tubes and accompanying ordinary DNA, plus reconnection of U-shaped magnetic flux tubes assignable to the magnetic bodies of biomolecules and allowing them to recognize each other, are the basic elements. The model has evolved from the attempts to understand water memory and homeopathy in TGD framework [K53].

Both 7 Hz ELF radiation and scattering of laser light would both generate dark photon (large Planck constant) spectrum with a wide spectrum of frequencies but with the same energy which in Gariaev's experiments would naturally be the energy of scatter laser light. The dark photons would provide representation for DNA codons. If 7 Hz frequency radiation involves dark photons with energies of visible photons transforming to ordinary photons before scattering from DNA the outcome would be same as in Gariaev's experiments.

This picture conforms with Gariaev's hologram idea and also with TGD based vision about living matter as a conscious hologram [K23]. The laser beam that Gariaev has used and the 7 Hz irradiation (involving dark ELF photons at bio-photon energies) would act as a reference beam allowing to read a biohologram coded by DNA and its magnetic body. The outcome is dark photons with same energy but with varying values of Planck constant and thus with varying frequencies propagating along magnetic flux tubes to the target, which could be exclusion zone (EZ). Flux tubes are characterised by h_{eff} and magnetic field strength B_{end} determining cyclotron frequency (coded by the transversal area by flux quantization if monopole flux is in question). Metabolic energy is needed to create EZ and could be provided either by the radiation itself or by the repeated heating. Negentropic entanglement is generated and creates the correlation between dark (phantom) DNA codons and ordinary DNA codons.

The following involves same elements as the model discussed in [K127] but there are also new elements due to the developments in the model of dark DNA allowing to imagine a detailed mechanism for how water can represent DNA and how DNA could be transcribed to dark DNA. The transcription/association represents a rule and rules are represented in terms of negentropic entanglement in TGD framework with pairs of states in superposition representing the instances of the rule. Transition energy serves as a characterizer of a molecule - say DNA codon - and the entangled state is a superposition of pairs in which either molecule is excited or dark DNA codon is excited to higher cyclotron state with same energy: this requires tuning of the magnetic field and sufficiently large value of h_{eff} at the flux tube. Negentropic entanglement is due to the exchange of dark photons: this corresponds to wave DNA aspect. Dark cyclotron photons also generate negatively charged exclusion zones (EZs) discovered by Pollack and in this process transform part of protons to dark ones residing at the magnetic flux tubes associated with EZs and forming dark proton sequencies.

2.10.1   Some Background

The model for remote replication involves the following basic building bricks.

1. Dark variant of DNA realized as dark proton strings representing dark nuclei.

2. The identification of bio-photons as decay products of dark cyclotron photons with large value of h_{eff} having universal energy spectrum due to the condition $h_{eff} = h_{gr}$.

3. TGD explanation for the fourth phase of water discovered by Pollack [L23] and characterized by negatively charged exclusion zones EZs generated by radiation.

4. A model for the radiative coding of DNA creating 1-1 correlation between ordinary and dark DNA codons and between two dark DNA codons.

Dark DNA as dark proton strings

TGD leads to a model of nuclei as nucleons strings [L3]. The model generalizes to the dark matter sector [L3, K53].

1. I have proposed the notion of dark DNA realized as dark proton sequences (3 quark states), which I have argued ton basis of a simple model to form representations for DNA, RNA,

amino-acids and even tRNA is central for TGD inspired biology. Biochemistry would define only a secondary representation for more fundamental realization of genetic code and analogs of basic biomolecules in terms of dark nuclear physics.

I have conjectured that translations, transcription, etc generalize and apply to pairs of ordinary and dark and dark and dark DNA and amino-acids. One could even consider that dark DNA would make possible induction of genetic changes: transfer dark DNA inside germ cells and transform them to ordinary DNA and attach to existing DNA. If dark DNA can be generated by radiation as wave DNA notion suggests then radiation from other cells to germ cells could induced genetic changes. Living systems would have kind of Research and Discovery apartment developing new candidates for genes. Evolution would be the opposite for blind random trials.

2. I have also proposed that immune system could have developed from what is basic mechanism of homeopathy and water memory. The magnetic bodies of water clusters mimic invader molecules - or rather their magnetic bodies. What is needed is a representation for cyclotron frequencies so that radiation would emerge in this phase. Cyclotron frequency spectrum would represent the invader and the simplest mimicry of invader molecule would be water structure with magnetic body characterized by same cyclotron frequency spectrum: water memory in short. Also the braiding of the magnetic body of the invader might be mimicked.

Protein folding might be a chemical representation for this braiding and the proteins of immune system might mimic the braidings of the magnetic bodies of the invader molecules. DNA in turn would give a symbolic representation of proteins allowing to construct them when needed. Ordinary DNA and proteins would have been preceded by dark DNA and dark proteins. I have even proposed an interpretation of genetic code based on the idea that it represents the dynamical evolution of braiding of the magnetic body - or 2-braiding [K88].

The basic mechanism of directed attention or sensing the presence of the invader molecule would be reconnection of U shape flux tubes of the magnetic bodies of the two system. Also resonant interaction by cyclotron radiation inducing cyclotron transitions is expected to be an essential piece of the mechanism. Magnetic body of water cluster could tune the thickness of flux tube so that the magnetic field is same as that in the flux tube of invader molecule so that primitive consciousness and act of free will would be involved.

3. Suppose that DNA codes for proteins, their cyclotron frequency spectrum and their braiding and knotting in protein folding in turn representing invader molecule. Is the frequency spectrum all that is needed to represent DNA and construct its dark variant? The experiments of Benveniste and followers [I48, I49] suggest that invader molecules are indeed represented by the cyclotron frequency spectrum alone. This would suggest connection with wave DNA concept.

Universality of cyclotron energy spectrum and bio-photons as decay products of dark photons

There are good empirical motivations [K83] to expect that the cyclotron energy spectrum is universal and in the range of bio-photon energy spectrum. This is achieved if h_{eff} is proportional to the mass m of the charged particle so that cyclotron energy $\hbar_{eff}eB/m$ is independent of mass and same for all charged particles.

Universality follows also from the condition that gravitational and biological Planck constants are identical: $h_{gr} = h_{eff}$, where $\hbar_{gr} = GMm/v_0$ is the gravitational Planck constant introduced by Nottale and assigned with the flux tubes mediating gravitational interaction in TGD Universe. The condition states that electromagnetic and gravitational flux tubes have same the value of effective Planck constant meaning that also gravitation would become a key player in biology.

Fourth phase of water, EZs, and metabolic role of cyclotron radiation

The experiments of Pollack [L23] suggest a partial answer to the question. in terms of what he calls fourth phase of water containing negatively charged regions, exclusion zones (EZ) of size up to 200 micrometers.

1. Irradiation of water by visible light generates negatively charged regions which he calls exclusion zones (EZs). The energy goes to the formation of electric voltage between exterior and interior and is analogous to cell membrane potential. Predecessor of cell could be in question. Some fraction of protons must go outside the system and my proposal is that it goes to magnetic flux tubes and forms dark proton sequences defining the analogs of basic bio-molecules. The $H_{1.5}O$ stoichiometry of EZs [L23] characterizing also earlier findings suggesting that one fourth of protons of water are dark in attosecond time scale (not visible in electron scattering and neutron diffraction) suggests that every fourth proton disappears from EZ. This anomaly was one of the strong motivations for taking the idea about dark matter as large h_{eff} phases seriously [K46].

   These structures would be involved also with water memory and homeopathy and immune system would have emerged from these. Free energy researchers know these regions quite well [H9] (no-one of course takes them seriously!) and they can be generated by just feeding energy to system used as metabolic energy. In homeopathy the mechanical agitation would do this and induce replication and perhaps even evolution of the resulting primitive lifeforms. Cavitation, use of strong electric field, maybe even heating used in PRC, etc... are possible mechanisms of energy feed.

2. The cyclotron radiation at cyclotron frequencies associated with flux tubes emanating from DNA codons could provide the energy needed to induce the formation of EZs. This would be the first function for the radiation.

3. If the DNA end of flux tube contains dark proton in state which corresponds to the DNA in one-one manner then the mass of the dark proton state would assign to it a unique cyclotron frequency distinguishing between DNA codons. The challenge is to understand the mechanism of DNA dark DNA pairing and dark DNA-dark DNA pairing and one expects resonant binding by exchange of dark cyclotron photons.

Pairing ordinary and dark DNA codons and two identical dark DNA codons by negentropic entanglement

One should understand the pairing of ordinary and dark DNA. As a matter fact, this pairing defines a realization of the genetic code as a physical 1-1 correlation of DNA codons with some physical states. I have consider this kind of realizations also in the model of DNA as topological quantum computer. The following realization relies on resonant interaction by exchange of dark cyclotron photons and can be seen as radiation based.

1. The most natural association between ordinary and dark DNA would via energy resonance. The energy for some molecular transition of DNA (in bio-photon energy range by argument below) would be same as cyclotron energy for the codon with large value of $h_{eff} = n \times h$ making cyclotron energy large.

2. By suitably tuning the value of the magnetic field B associated with the flux tube accompanying ordinary DNA codon the dark cyclotron energy can be tuned to be equal to the value of some biochemical transition energy of DNA, which is in visible and UV range typically - that is in the energy range of bio-photons.

3. Classically DNA codon and its dark variant can be thought of as exchanging forth and back dark photon at resonance frequency and become strongly correlated in this manner like tennis players during game. Quantum mechanically one has quantum entangled Schrödinger cat like state in which state pairs have same total energy but individual states do not have well-defined energy.

4. The correlation between dark proton states at two ends of flux tube would be realized as formation of bound state via resonant exchange of dark cyclotron photons. Negentropically entangled [K70] superposition for which simplest the possible form is $|n\rangle|n+1\rangle + |n+1\rangle|n\rangle$ of paired cyclotron states would be generated. DNA and dark DNA codons would pair to a negentropically entangled state in similar manner. Recall that in TGD framework negentropic entanglement (NE) carries potentially conscious information: the state represents a rule whose instances correspond to the state pairs in the superposition [K70].

5. One can consider also 3-particle NE of DNA codon and 2 dark DNA codons which is super-position of three 3-particle states with one particle excited to higher energy state with the same energy. DNA codon would be excited chemically and dark codons excited to cyclotron state $(n \to n+1)$. 3-dimensional permutation symbol defines this kind of state. Also NE for larger number of particles is possible.

The tuning of the flux tube magnetic field to make cyclotron energy equal to chemical transition energy is possible for arbitrary biochemical transition energies and the association of dark proton states to arbitrary biomolecules is in principle possible via same mechanism. This would be essentially a symbolic representation of biomolecule, a name for molecule. If one has some number of different molecules able to form sequences, these sequences can be remotely reconstructed by using the cyclotron frequencies and transversal flux tubes associated with the template to generate the EZs and the name of the polymer to which the building bricks bind resonantly.

If the condition $h_{eff} = h_{gr}$ holds true, one can use instead of dark proton sequences sequences of *any* dark charged particles - say electrons and ions. Hence almost an unlimited repertoire of representations arises. These correspondences need not to be one-one. For instance, DNA-amino-acid 64-to-20 correspondence is possible to realize with the help of dark variants of DNA codons and amino-acids and also the partially or totally dark variants of this correspondence are possible.

This pairing mechanism would allow resonant interactions of the ordinary DNA codons in water and dark DNA codons induced by the dark cyclotron radiation and could play key role also in ordinary DNA replication and also in the remote replication reported by Montagnier [I66] and Gariaev [K127]. A phase transition reducing h_{eff} would bring ordinary and dark codon together and ordinary biochemistry would take care of the rest. Clearly, this mechanism would also allow biomolecules connected by magnetic flux tubes to find each other in molecular soup with pairing following by a phase transition reducing h_{eff}.

2.10.2 Does Remote Replication Apply Same Mechanism As MimicryOf Invader Molecules In The Case Of Water Memory?

Somehow the irradiation of water sample with the cyclotron radiation generated by real DNA should induce or be involved with the generation of dark DNA representing the ordinary DNA and the PCR process would use this dark DNA as template an involves pairing of ordinary and dark DNA nucleotides. How this could happen in TGD Universe?

The mechanism of remote DNA replication without chemical template would be essentially the same as in the TGD based model of water memory [K53] underlying also the model of home-opathy circumventing the ultra-naïve skeptic argument that homeopathy is not possible because the density of molecules dissolved in water is practically zero.

The cyclotron frequency spectrum allows to create EZ whose magnetic body mimics the invader molecule. Resonant formation of negentropically entangled pairs would define a realization of genetic code based on radiation and dark cyclotron radiation would give rise to the formation of EZs and accompanying dark proton sequences.

In the recent case invader molecule would be replaced with DNA expressing its presence using dark cyclotron radiation propagating along the flux tubes transversal to codons and forming part of the magnetic body of DNA. The magnetic flux tube of ordinary DNA codon realizing dark proton sequence as dark variant of DNA codon would generate its own representation by generating EZs in water.

The rules would be following.

1. Magnetic fields at U-shaped flux tubes associated with codons and dark codons must be equal so that also cyclotron frequencies coding for dark proton masses and therefore for dark proton states would be equal so that frequency and energy resonance is possible and negentropically entangled state is formed. This assigns by resonance mechanism to the second end of flux tube same dark proton state as to the end near ordinary DNA. Recall that U-shape is essential for bio-super-conductivity based on large value of h_{eff} making possible large and negative spin-spin interaction energy for electrons of pair located at parallel flux tubes [K25, K89].

As described, binding is generated by resonant exchange of dark cyclotron photons between the ends which are in superposition of different cyclotron states. Magnetic field value in turn

corresponds directly to ordinary DNA codon - or rather its transition in bio-photon energy range. It is essential that the value of magnetic field codes for ordinary DNA codon via a biochemical transition energy associated with it. One can imagine that magnetic body can tune the value of field by changing the transversal area of the flux tube carrying monopole flux (possible in TGD due to the CP_2 topology). Similar tuning would be involved when the magnetic bodies assignable to EZs detect possible invader molecules. Interestingly, the impurity molecules inside EZs are removed by unknown mechanism citebbioPollackYoutube.

2. Dark DNA codons associated with DNA would have U-shaped flux tubes which for large h_{eff} would extend to the water sample containing building bricks of DNA and catalyst. The flux tubes associated with dark DNA and building bricks of ordinary DNA would reconnect resonantly and lead to remote replication of DNA strand.

This option is definitely not the only possibility one can imagine but represents the general principle. For instance, one can consider using only DNA-dark DNA complex and inducing h_{eff} increasing phase transition transferring the dark DNA strand to the volume of the water sample. The mechanism allows also to consider remote translation of genes to proteins. The possible medical applications of this in a situation in which the DNA of the patient has suffered a mutation causing a disease are obvious.

2.11 Remote replication again

In TGD inspired vision about quantum biology relying on the notion of magnetic body (MB) carrying dark matter as phases of ordinary matter with effective Planck constant $h_{eff} = n \times h_0$ one ends up with the notion of dark DNA realized as sequences of dark protons and to the surprising finding that dark proton triplets realize vertebrate genetic code and basic biomolecules DNA,RNA,tRNA, and amino-acids [L34, L55].

The objection against dark photon 3-chords (3-photon states) is that the simultaneous emission of 3 dark photons used in communications as 6-bit unit is extremely non-probable. A possible solution of the problem is that dark photons carry number theoretic color associated with Z_3 subgroup of Galois group. Number theoretic color confinement would imply that only 3-chords can appear as asymptotic states analogous to baryons. If dark protons are also number theoretic color triplet, dark codons must consists of 3 protons and therefore also ordinary codons have 3 letters.

The findings of Montagnier *et al* [I66] (`http://arxiv.org/abs/1012.5166`) raise the possibility of remote replication of DNA. Montangier's experiment involves two chambers A and B. A contained water and genes and B water and DNA nucleotides. There were channels between the chambers but so thin that DNA could not get through. Besides this there was present em field with 7 Hz frequency. Same genes as in A appeared also in B. As if remote replication of genes in A had happened in B. I have written an articles about Montagnier's findings [L10, L20]. Gariaev has reported similar phenomenon already before Montagnier *et al*: we wrote together an article discussing TGD based model for the finding [K127].

How did the genetic information pass to B and how the remote replication took place? Somehow the radiation made the remote replication possible or at least more probable. Clearly the information about gene - not only about codons but also about their order and relative positions - should have been communicated from A to B. I have already earlier considered this problem but found no satisfactory solution to it.

Concerning the role of the 7 Hz frequency, there are two hints.

1. The nominal value of the lowest Schumann frequency is 7.8 Hz, not far from 7 Hz. Could one think that macroscopic quantum coherence in the scale of Earth was involved. 7.8 Hz correspond to wavelength equal to circumference of Earth.

    "Endogenous" magnetic field $B_end = .2$ Gauss identifiable as the monopole flux part of the Earth's magnetic field $B_E = .5$ Gauss explains the findings of Blackman [J28] and others about quantal looking effects of radiation at frequencies seem to be multiples of cyclotron frequencies of biologically important ions.

    The problem is that the energies of cyclotron photons are ridiculously small for ordinary value of Planck constant. This was one of the motivations for the hypothesis that dark

matter corresponds to phases of ordinary matter with effective Planck constant $h_{eff} = n \times h_0$ [K88, K89, K90]. The cyclotron frequency of K ion is $f_c(K^+) = 7.1$ Hz. The flux tubes with length of corresponding cyclotron frequency are also of the order of Earth circumference.

This raises several questions.

1. Did water generate flux tubes with magnetic field with frequency equal to $f_c(K^+) = 7.1$ Hz and strengthening coupling to a radiation with Schumann frequency or K cyclotron frequency or both so that the communications with the MB of Earth or/and layer of MB corresponding to K cyclotron was strengthened? The TGD based mechanism of water memory [K53] would be involved.

2. Did this make the remote replication more probable? How?

3. What DNA actually looks like in TGD Universe? What actually happens in DNA replication? What could happen in remote DNA replication?

In the sequel the questions whether cyclotron frequency or Schumann frequency or both were involved and how their presence made possible remote replication remain without detailed answer although it is clear that the presence of dark photons with this frequency should make possible the control by MB generating coherence of ordinary matter in the scale determined by the sizes of the chambers. These questions however led to a considerable increase in the understanding of dark variants of genetic code predicted by TGD [L34, L19, L75].

1. To understand remote replication one must understand replication. Dark codons do not decompose into letters like chemical codons: this poses strong constraints on the replication and transcription if one assumes DDNA-DNA-pairing. These constraints strongly suggests that the nucleotides in the water environment of DNA are not actually free but form loosely bound triplets representing codons and bound with DDNAs. This means a new variant of genetic code realizing codons as loose triplets of nucleotides in the water environment.

2. This proposal brings in mind TGD based model for viruses, which can decompose into pieces shared between several host cells and re-combine later as also the observation that the dense states of bacteria population have resemblance to multi-cellular embryos. The common TGD inspired explanation [L85] would be that the pieces of virus and cells of bacterial population are connected by magnetic flux tubes and form a single loosely bound unit at the level of MB. The prediction is that replication occurs in codon-wise manner: this has been observed to be possible for RNA [L60]. It might be that the loose nature of exotic DNA codons allows this to occur quite generally.

3. Remote replication in this framework reduces to ordinary replication in TGD sense if also dark genes are formed by attaching flux tubes characterizing dark codons to a long flux tube associated with gene. Remote replication requires that the portion of dark gene accompanying ordinary gene is transferred from chamber A to chamber B in the experiment of Montagnier.

2.11.1   Three variants of genetic code

The notions of MB and view about dark matter leads to 3 variants of genetic code.

1. The notion of MB suggests that dark proton sequences assumed to explain Pollack effect (`http://tinyurl.com/gwasd8o`) [L23] realize dark genetic code. Dark DNA (DDNA) codon would correspond to 3-proton triplet assignable to closed flux tubes attached to a a long flux tube by U-shaped flux tube appendix giving rise to dark gene (`http://tinyurl.com/jgfjlbe`). Attaching means formation of U-shaped appendices from long flux tube and DDNA codon which reconnect to a pair of flux tubes. 3-proton states define dark analogs of DNA, RNA, tRNA, and amino-acids (DDNA, DRNA, DtRNA, DAA) [L34, L55]. The numbers of DDNAs coding for given DAA are same as for vertebrate genetic code.

2. Second dark code is needed for communications and realizes genetic codons as dark 3-photon states - 3-chords of bio-harmony [L19, L69, L75] (http://tinyurl.com/yad4tqwl). The model emerged from a model of musical harmony based on icosahedron and tetrahedron. 12-note scale is identified as a Hamiltonian cycle - a path going through all 12 vertices of icosahedron - such that going from vertex to neighbor corresponds to quint. Hamiltonian cycles have cyclic group Z_n, where $n = 0, 2, 4, 6$ is the order of the group, as symmetries. $n = 0$ corresponds to chaotic orbit and disharmony. Each of the 20 faces - triangles - corresponds to a chord of given harmony.

   One identifies the orbit of given face as DAA coded by faces (DDNAs) at the orbit. By combining 3 harmonies with $n = 6$, $n = 4$ and $n = 2$ one obtains 20+20+20 chords and the numbers of DNA coding given AA are essentially those in vertebrate code. By gluing tetrahedron to one face one obtains 4 additional chords (DDNAs) and 1 additional note very near to one of the notes of Pythagorean scale, whose problem is that it does not quite close. The numbers for analogs of DNA codons coding for for given DAA are same as for vertebrate code.

   The chords would be represented as "music of light" as states of 3 dark photons. Music expresses and creates emotions and bio-harmony would provide a physical correlate for emotional states at molecular level [L61].

3. Dark codes would be fundamental and chemical code would be their mimicry. One expects DDNA-DNA pairing with DDNA codons represented as dark proton triplets. DDNA codons and dark photon chords have no decomposition to letters (chinese and western languages provide an analog). This suggests that DNA replication and transcription cannot take letterwise but but codon-wise. Amazingly, there is evidence that DNA replicates in codon-wise manner during RNA era: I have commented this in [L60].

   Nucleotides/letters in the water environment of DNA double strand should appear as loosely bound but correlated triplets of nucleotides associated with closed flux tubes containing dark DNA codon. They would represent exotic DNA codons. This would force fixed order of nucleotides essential for the code. By absence of valence bonds between nucleotides they would be effectively free but strongly correlated. This representation of the code would be crucial for replication and transcription.

These 3 codes allow to understand replication and transcription of DNA replaced in TGD with DDNA-DNA pair. The prediction is that the replication takes place codon by codon and might kill the model.

A model of replication based on this picture generalizes to remote replication suggested by the findings of Montagnier [I66]. The DDNA codons of ordinary DNA strand would be attached with a long side of closed flux tube as dark gene. In remote replication h_{eff} of dark gene would change and dark gene would be transferred to chamber B from A. After that the replication would proceed as usual.

2.11.2 An objection against bio-harmony

There is a serious objection against the realization of dark genetic code in terms of bio-harmony. The emission of 3 dark photons simultaneously looks extremely non-probable process.

Number theoretical physics suggests a solution of the problem. Number theoretical physics [L49] (http://tinyurl.com/zylrd7w) is a central part of quantum TGD and quantum biology and provides physical correlates for cognition. It explains dark matter as $h_{eff} = nh_0$ phases of ordinary matter with n identified as order of Galois group of extension of rationals and as dimension of extension. This picture predicts automatically evolution as increase of n in quantum jumps.

1. There is analogy with color confinement. Baryons consist of 3 quarks. Color symmetry is a symmetry of strong interactions and quarks form color triplets. Free quarks do not appear in the final states, which givs rise to color confinement: only color singlets, in particular baryons consisting of 3 quarks and mesons consisting of quark and antiquark are possible.

   This suggests that also now there must be a symmetry such that dark photons have new quantum numbers, which vanish for physical states such as dark photon triplets.

2. What these quantum numbers could be? The only candidate, which comes in mind are discrete quantum numbers related to the Galois group of extension of rationals defining number theoretic symmetry. For ordinary $h = 6h_0$ Galois group has $n = 6$ elements and equals to $Z_6 = Z_2 \times Z_3$.

   It appears as subgroup of higher Galois groups for which $h_{eff} = n \times h = 6nh_0$ one would have extension of extension. Z_3 confinement would require 3-photon states, which are Z_3 singlets with number theoretic colors summing up to zero. One would obtain only 3-chords. Ordinary photons would be Z_3 singlets.

3. Also the 3 protons of DDNA codon could form Z_3 triplet. Number theoretic color confinement would allow only 3-proton triplets. Genetic code is predicted correctly and the number letters in the codons is predicted to be 3.

   This raises two interesting questions.

1. Quantum-classical correspondence (QCC) is a exact part of TGD. Therefore I have considered the possibility that all physical symmetries could have number theoretical space-time correlates. However, at space-time level one cannot have representations of color group with non-vanishing triality $t = 0, \pm 1$. Same applies to spin half-odd integer representations of rotation group. Could $SU(2) \times SU(3)$ representations with triality $t = \pm 1$ and spin half-odd integer have triplet representation of Z_3 and double representation of Z_2 as space-time correlates? Z_6 would be the minimal Galois group allowing to realize spin and color for quarks.

2. Number theoretical physics predicts that Galois group for any extension of rationals acts as new hidden discrete symmetry. Could number theoretical confinement implying new selection rules be true quite generally? The larger the degree n of extension (h_eff), the larger the scale in which confinement holds true, is. For instance, genes could be analogs of color singlet many particle states for a larger subgroup.

   This is not the only option. I have already earlier considered with Peter Gariaev [K127] a proposal in which dark photons would communicate the genetic information from A to B. The problem is how the massless extremals (MEs) [K14] associated with them can be parallel and of same length: this would require that they form a quantum coherent entity. Could one consider a modification of the above proposal assuming that gene is an entity of N codons confined number theoretically? Could one can speak about dark photon genes as composites of N dark photon 3-chords? The information would be sent by dark photon gene representing entire music piece, as one might say. In chamber B energy-frequency resonance would generate a linear configuration of exotic codons, which would reduce to DDNA-DNA pair when h_{eff} is reduced.

2.11.3   DDNA-DNA, DDNA-DDNA, DDNA-exotic DNA pairings

The idea about MB as boss of BB suggests that DNA is accompanied by DDNA. DDNA would be the fundamental DNA and ordinary DNA emerged later as a kind of mimicry and there would be DDNA-DNA pairing.

   The basic problem problem is that DDNA codons do not allow decomposition into letters like DNA codons. It seems that replication and transcription must occur codon by codon rather than letter by letter. For translation of mRNA this is indeed the case: tRNA are the basic objects. Could this be true in modified sense also for replication and transcription? In fact, RNA can replicate in codon-wise manner [L60]. Could this occur quite generally, and could the codons for replication believed to occur letter-wise be present in a latent manner?

DNA and DDNA codons

At least 3 new kind of codons are predicted (`http://tinyurl.com/yygqen5g`).

1. Also ordinary DNA codons involve flux tubes. Valence bonds between nucleotides of DNA strand and hydrogen bonds in double strand involve flux tubes or pairs of them.

2. DDNA codons are paired with ordinary DNA codons of DNA strand. DDNA codons would correspond to dark proton triplets at flux loops being analogous to tritium and ^{3}He. The model for remote replication requires that DDNA codon loops are connected to long closed dark gene flux loop by U-shaped appendages - attached to dark gene.

   If DDNA and DNA codons are paired with ordinary DNA by energy resonance there is no need for flux tube contacts between the triplets.

3. Dark codons as dark photon 3-chords are predicted. Couple to DDNA by energy-frequency resonance and to DNA by energy-resonance.

4. Exotic DNA codons are required by the model of replication. DNA nucleotides in environment would combine to exotic codons paired with DDNA codons.

What various pairings do look like?

There would be 3 kinds of pairings. This would predict that nucleotides appear as apparently free entities in the water environment.

1. DDNA-DNA pairing in DNA strand. Different values of h_{eff} do not allow flux tubes contacts. Energy resonance only.

2. DDNA-DDNA pairing in DNA double strand is not necessary in geometric sense as flux tube connections because hydrogen bonds pair DNA codons and energy resonance pairs DDNA strands to DNA codons. DDNA codons could be however located along dark gene flux tube and attached to it by flux tube pairs.

3. DDNA-exotic DNA pairing would take place in environment. Nucleotides of exotic DNA would be attached to closed DDNA codon flux tubes. h_{eff} would be larger than for DDNA codon in double strand. There would be no valence bonds between nucleotides. The ordering of letters would be forced by flux tube containing the dark codon and energy resonance. One obtains correct codon if the orientation of the flux tube matters (ABC and BCA correspond to different energies in energy resonance). Strong parity breaking allowed by TGD and realized in living matter would imply it.

   This would solve the basic problem. Codon would be secretly present since there would be no valence bonds, which together with small string tension would mean that nucleotides are effectively free.

4. It is of course not clear whether this is enough to explain experimental findings. If one can demonstrate experimentally that the build-up of DNA strand in replication really occurs in letter-wise manner, the proposed model must be modified (not of course clear whether this is possible). The codon-wise coding, which can occur for RNA [L60] could be understood if the value of h_{eff} for DRNA strand can be same or nearly the same as in RNA strand.

2.12 TGD Inspired Model For The Formation Of Exclusion Zones From Coherence Regions

There is a talk of Mae-Wan Ho (`http://tinyurl.com/ybbyn4pc`) in Conference on the Physics, Chemistry and Biology of Water 2014. It is a very nice representation and I learned new facts highly relevant for my own work.

   Some background articles might be helpful. Mae-Wan Ho [I101] has proposed that there exists superconducting liquid crystal water aligned with collage fibres. Giudice *et al* [I46] have proposed that water dynamics is at the root of metamorphosis in living matter: this involves the notion of water coherent region (CD) with size scale of 1 micrometer. I have not considered this notion in TGD framework earlier but TGD strongly suggests that the four Gaussian Mersennes $M_{G,k}$, $k = 151, 157, 164, 167$ with corresponding p-adic length scales coming as $L(k) = 2^{(k-151)/2} times L(151)$, $L(151)$=10 nm are important in biology: $k = 167$ corresponds to 2.5 micrometers. Pollack and *et al* [I147, I126] have introduced the concept of exclusion zone (EZ)

with size scale of 200 nm and related notion fourth phase of water. TGD inspired model of EZ involves in essential manner dark protons at magnetic flux tubes assignable to EZ [K83, K88].

 The main points of Mae-Wan Ho's talk are following.

1. Protons make water a conductor, maybe even superconductor. In TGD framework the statement would be that dark protons flowing along magnetic flux tubes make this possible. Personally I believe that electronic and even ionic Cooper pairs are are involved and TGD based model of cell membrane [K106] assumes these super-conductivities relying on the notion of dark matter realizes as $h_{eff} = n \times h$ phases.

2. The water associated with collagen networks appears as superconductor and superfluid in nano-scales. Also this is very attractive idea and if the $h_{eff} = h_{gr}$ condition holds as some arguments suggest, then superfluidity allowing macroscopic quantum coherence with gravitational Compton length having no dependence on the mass of particle becomes possible [K83]. This is due to two facts. First, one has $\hbar_{gr} = GMm/v_0$, where M can be identified as dark part of the Earth's mass, m is the mass of the particle and v_0 is velocity parameter. Secondly, Compton length is inversely proportional to the mass. One of the strange effects involved with superfluidity is fountain effect explained elegantly by macroscopic quantum gravitational coherence: water would effectively defy gravitation: this effect might allow testing of the hypothesis.

2.12.1 CDs And EZs

Mae Wan-Ho talked about and compared two notions: CDs (coherent domains of water with size of about micrometer postulated by quantum field theoreticians, in particular Emilio del Giudice) and EZs (exclusion domains with size about 200 micrometers discovered by Gerald Pollack and collaborators experimentally). Note that in Zero Energy Ontology (ZEO) I talk about causal diamonds (CDs), which are typically much larger than CDs of Giudice *et al.*

1. Inside EZ the water forms layered structure consisting of hexagonal layers and the stoichiometry is $H_{1.5}O$ so that every fourth proton must be outside EZ (proton is not accompanied by electron if charge separation takes place: EZ is indeed negatively charged so that one obtains different pHs inside EZ and in its exterior). This state is experimentally heavier than ordinary water.

2. So called tetrahedral or 4-coordinated water is assigned with CDs. CDs and EZs could correspond to two different p-adic length scales in TGD framework. This state would be less dense than ordinary water. Both CD and EZ contain plasma of almost free electrons. CDs are excited to 12.06 eV just.5 eV below the ionizing potential 12.56 eV..5 eV which is the nominal value of metabolic energy quantum - probably not an accident.

2.12.2 TGD Inspired Model For CDs And EZs

I try my best to summarise some very interesting points of the talk and develop in more detail TGD inspired model for EZs and their formation, and the TGD view of metabolism leading to a prediction of new form of metabolism involving dark UV photons from Sun.

1. The splitting of ordinary water H_2O to $2H^+ + 2e^- + O$ is a key step in photosynthesis. In particular, it produces oxygen without which which we cannot survive. The splitting process involves two ionizations. The ionisation energy of the first electron 12.56 eV and in ultraviolet much above the metabolic energy quantum around.5 eV. How the splitting of water can be achieved at all? This looks like a very real problem!

2. CDs/EZs could be the solution to the problem. Inside CD the energy for the splitting of water is much smaller due to the fact that electrons are almost free as already mentioned: if the splitting energy equals to the so called formation energy, it is about.41 eV for CD: nothing but the metabolic energy quantum! Also at the interace of EZ just above the boundary of EZ the electronic states are excited and only an energy of.51 eV - known as formation energy - is needed for the splitting. This suggests that metabolic energy quanta are used to generate

EZs and/or CDs in the fundamental step metabolism. Also irradiation at these energies generates CDs/EZs.

3. My layman logic says that formation energy for EZ must correspond to the energy needed to increase the size of /EZ by a minimum amount. In TGD model this would mean creating one proton-electron pair such that electron remains inside the EZ, whose size thus increases and proton becomes dark proton at dark magnetic flux tube. This step would be also a key step in the splitting of water. Splitting of water and growth of EZ would be essentially the same process. In the case of CD it would seem that charge separation takes place inside CD in the splitting and proton can go outside.

What comes in mind that the formation of CDs requiring large excitation UV energy of 12.06 eV precedes that of EZs. After the formation of CD and almost free electrons only metabolic energy quantum per proton is required to kick single proton to dark magnetic flux tube. This would conform with the fact that CD radius is about 200 times larger than that of CD meaning that volumes are related by a factor $8 \times 10^6 \simeq 2^{23}$. The formation of EZ would transform tetrahedral water to the hexagonal $H_{1.5}O$ and suck protons to dark protons at magnetic flux tubes. If this picture is correct, the proper identification of formation energy for CD would be as absorption energy for CD equal to 12.06 eV and in UV. Recall that bio-photon spectrum extends to UV and dark photons with this energy could be responsible for the formation of CDs. This would adde dark photons transforming to bio-photons to the picture.

The formation of EZ can be seen as pulling out one ordinary proton from ordinary water just above the surface of the EZ and making it dark proton at a magnetic flux tube assignable to the EZ and perhaps connecting it to neighboring EZ for form a quantum coherent network. Dark proton would serve as a current carrier and make water a conductor and perhaps even super-conductor. Even superfluidity can be considered.

4. The metabolic energy quantum.5 eV can be also assigned with hydrogen bond. Could the process of generating dark proton and increasing the size of EZ by one electron involve cutting of the hydrogen bond binding the proton to the water outside. If so then the only thing keeping the excited water inside CD as a coherent phase would be the bond energy of hydrogen bonds! Maybe this is too simplistic.

I have proposed earlier that hydrogen bonds are short magnetic flux flux tubes, which can suffer h_{eff} increasing phase transition. These flux tubes could in turn experience reconnections with U shaped large h_{eff} flux tubes and get connected to the dark web. Mae-Wan Ho also tells that the transfer of proton from covalent OH bond to the middle of hydrogen bond happens with a considerable probability. Could this step precede the increase of h_{eff} and reconnection? This would give a connection with hydrogen bonding about which Mae Wan-Ho also talked about. These naïve models of course cannot be correct in detail but give hopes about fusion of existing chemical thinking and new quantal notions.

5. A process bringing in mind the formation of EZs occurs as one perturbs molecular bio-systems - that is feeds energy into it. The system "wakes up" from "winter sleep", the globular proteins, which are in resting state with hydrogen bonds at their surface forming kind of ice layer unfold and protein aggregates are formed. Molecular summer begins and ceases when the energy feed is over. Cellular winter begins again. Maybe cellular summer is just temporary formation of EZ layers around the protein involving melting of hydrogen bonds and generation of dark protons making system conscious!

2.12.3 Is A New Source Of Metabolic Energy Needed?

What remains to be understood is the process generating CDs: where could the UV photons with energy 12.06 eV come? Clearly a new form of metabolism is involved and the only source of energy seems to be the Sun!

1. Solar radiation cannot however provide UV photons as ordinary photons since UV radiation at these wavelengths is absorbed by the atmosphere. In TGD framework a reasonable candidate for dark radiation with energies in UV range is dark cyclotron radiation with energy

$E = h_{eff} \times f$: biophotons would be produced in the transformation of dark cyclotron photons to ordinary photons.

2. Could part of solar UV radiation transform to dark UV photons at magnetic flux tubes of even size scales larger than that of Earth predicted by the model of EEG and arrive along them through the atmosphere? The presence of a new source of metabolic energy is in principle a testable prediction: is the energy feed from the visible part of solar radiation really enough to cover the metabolic energy needs? Here one must however take into account the fact that the UV energy would be received by water. The water from which CDs are eliminated would not allow photosynthesis.

To sum up, if the proposed picture is correct photosynthesis involves formation of EZs and cellular respiration the inverse of this process. As discussed earlier, the purpose of metabolic processes would be basically generation and transfer of negentropic entanglement assignable to large h_{eff} states.

2.13   Connections To The Work Of Other Researchers In The Forefront

Many connections with the workers in the field have emerged. In the following I list some articles in chronological order. Some of the people included have not worked with remote mental interactions but in TGD world order their work relates rather closely to this field so that I have included them.

2.13.1   Mae Wan-Ho

Mae Wan-Ho is one of the pioneers of the new biology. She emphasizes the fact that genetic code is not enough to understand inheritance (see article *Mystery of Missing Heritability Solved* (see http://tinyurl.com/y7f4b5rz [I114]), that genes alone do not determine body patterns (see article it Genes don't Generate Body Patterns (see http://tinyurl.com/y9tyslwv) [I113]), that there are no genes for intelligence (see article *No Genes for Intelligence in the Human Genome* (see http://tinyurl.com/ycxdoz3h) [I115]). In TGD framework the notion of magnetic body could provide the umbrella concept suggesting braiding as a universal mechanism to encode interactions with environment to braiding.

Ho realizes the importance of water-protein interaction (see article *Proteins secret water music in nanospace* at http://tinyurl.com/ybdrrtft) [I116]. Ho dares also to speak about homeopathy and water memory (see *Quantum Coherent Water Homeopathy* at http://tinyurl.com/ydhwlbz7 [I116]). The TGD counterpart is the vision about cellular and molecular "seasons". External energy feed melts the "ice" formed by ordered water around globular proteins. This leads to new conformations and protein aggregation. This process also updates topological quantum programs by inducing time-like braiding changing space-like braidings of the perturbed part of the system with its complement.

Ho also emphasizes the importance of liquid crystal phases in biology. Liquid crystals are associated with cell membranes, cytoskeletal and muscle proteins, collagen and other connective tissue macromolecules, and also DNA in chromosomes [**?**] Ho assigns morphogenic fields with them (see *Liquid Crystalline Morphogenetic Field* at http://tinyurl.com/c4udjsm [I117]). Ho has introduced "Quantum Jazz" as a wonderful metaphor for what Bohm would have called active information and I call negentropic entanglement making possible highly correlated states in which particles are effectively free. Ho has proposed that these liquid crystals act as a holographic medium and based the proposal on the effects of polarized light [**?**] In TGD framework also magnetic flux tubes would be involved. Flux tubes would connect the basic units of liquid crystals to those of other liquid crystals. DNA nucleotides to lipids of nuclear or cell membrane [K5] (see http://tinyurl.com/ybyscdpt).

Space-like braiding is modified by liquid chrystal fluid flows defining time-like braidings (dance metaphor). Liquid crystals plus magnetic flux tubes could serve as the holographic medium storing dynamical patterns to spatial patterns and therefore defining also fundamental memory representations. The sensitivity of liquid crystal state and therefore of braiding to various parameters

such as em fields, temperature and pressures changes, hydration, pH, concentrations of various ions makes braiding an ideal mechanism for making living matter a hologram substrate.

Also topological quantum computation like processes would become possible. The fractality crucial for holography would correspond to the possibility of having flux tubes within flux tubes within.... In other words, one would have hierarchical braiding. Braids would decompose to braids which are braided in turn. As a matter fact, this braiding is central element of the dynamics of TGD Universe, not only of TGD inspired biology.

I have commented some of the articles of Mae Wan-Ho in the chapter *TGD inspired model for nerve pulse* (see `http://tinyurl.com/y8e5oqkm`) of [**?**]see the article *Can Water Burn?* at `http://tinyurl.com/y7pjv6eh` [D60]) and in the chapter *Quantum gravity, dark matter, and prebiotic evolution* (see `http://tinyurl.com/y8gr9enm`) of [K106].

2.13.2 Peter Gariaev

Peter Gariaev and his group have done a lot of pioneering work in bio-electromagnetism and the notion of wave DNA is due to him. The findings of Gariaev's group include the rotation of polarization plane of laser light by DNA [I53], phantom DNA effect [I54], the transformation of laser light to radio wave photons having biological effects [I55], the coding of DNA sequences to the modulated polarization plane of laser light and the ability of this kind of light to induce gene expression in another organisms provided the modulated polarization pattern corresponds to an "address" characterizing the organism [I53], and the formation of images of what is believed to be DNA sample itself and of the objects of environment by DNA sample in a cell irradiated by ordinary light in UV-IR range [I95]. The chapter "Model for the findings about hologram generatg properties of DNA" (see `http://tinyurl.com/y9ughr5f`) [K1] of book "Genes and Memes" represent an article written in collaboration with Peter Gariaev and published in DNADJ (DNA Decipher Journal) in January 2011. If the interpretation of the experimental data is correspond then dark matter at magnetic flux body assignable to DNA sample has been photographed. What would happen that incoming photons leak to the dark flux tubes in a phase transition changing the value of Planck constant, are reflected from the dark matter and transform back to ordinary photons generating the picture in the film.

"Quantum Model for remote replication" (see `http://tinyurl.com/ybvosy7h`) [K127] is second article written together with Peter Gariaev. There are three experimental guidelines: the phantom DNA [I54] identified as dark nucleon sequences in TGD framework and the evidence for remote activation of DNA transcription [I53] - both discovered by Gariaev's group - are assumed as the first two key elements of the model. The remote replication of DNA suggested by the experimental findings of Montagnier's group serves as a further guideline in the development of the model. Also the results of the latest experiment of Gariaev's group in many respects similar to that of Montagnier's experiment but differing in certain crucial aspects from it are used as input.

Polymerase chain reaction (see `http://tinyurl.com/ybv6mn5l`) (PCR) is the technique used in the experiments of Montagnier's group [I23] and later in somewhat modified experiment by Gariaev's group involving irradiation of the second test tube by laser light. DNA polymerase catalyzes the formation of DNA from existing DNA sequences serving as a template. Since the catalytic interaction of DNA polymerase takes place with already existing DNA sequence, the only possibility is that first some conjugate DNA sequences are generated by remote replication after which DNA polymerase uses these sequences as templates to amplify them to original DNA sequences. Whether the product consists of original DNA or its conjugate can be tested.

In TGD inspired quantum biology the representations of genes in terms of temporal patterns of em radiation could be in central role. TGD suggest concrete model for water memory in terms of the magnetic body of biomolecule whose cyclotron frequency pattern codes for the biological effects of the molecule. Water memory would mean that water can build magnetic bodies mimicking those of biomolecules or perhaps steal them in the process of dilution which involves the shaking of the solution. The basic problem of the model is how to the gene coded as a temporal field pattern could activate corresponding gene. It seems that the solution of this problem requires that also linear spatial pattern matters. A possible realization would be as planar sheets of magnetic flux tubes emerging from sender DNA and attaching to the target DNA and carrying the radiation. Remote replication would take place only if resonance condition for the frequencies depending on nucleotides is satisfied for each flux tube. Note that DNA as topological quantum computer relies

on similar flux tube structure.

TGD suggest also another representation of the genetic code in terms of dark nucleons [L3], [L3], which could be highly relevant for the realization of water memory in terms of a dark portion of water for which there exist empirical evidence [K45]. This dark portion would also explain the numerous anomalies of water. It became as a total surprise that the states of dark nucleons correspond in natural manner to DNA, RNA, tRNA, and amino-acids. DNA would define only one particular representation of the genetic code, which in the primary form would be realized at elementary particle level and that there could exists many representations of DNA. Also the model for DNA as topological quantum computer [K5] proposes a non-standard representation of the code.

The model inspires the proposal that the magnetic body of a polar molecule codes for it using dark nucleon sequences assignable to the hydrogen bonds between the molecule and surrounding ordered water layer. Quantum antenna mechanism would allow the immune system to modify itself by developing ordinary DNA coding for amino-acids attaching to and thus "catching" the polar molecule. The mechanism could be behind water memory and homeopathic healing. Every polar molecule in living matter would have dark nucleon sequence or several of them (as in the case of amino-acids) serving as its name. This would also associate unique dark nucleon sequence also with the magnetic body of DNA so that "DNA-dark DNA" association would be automatic. Same applies to mRNA and tRNA and amino-acids. The general idea is therefore that symbolic dynamics emerges already at the molecular level: the dark DNA sequence serving as a "name" of the molecule to high extent determines the dynamics just as in human society.

The existence of a multitude of representations of the code would not be too surprising when one realizes that the information processing performed by computers involves endless variety of different representations of various codes. The problem is about attitudes: the dogma that biology is nothing but chemistry is what is being challenged and we love dogmas because they liberate us from the burden of using our own brains.

2.13.3   Luc Montagnier

The article "DNA waves and water" by L. Montagnier, J. Aissa, E. Del Giudice, C. Lavallee, A. Tedeschi, and G. Vitiello [I66] has created quite a furor even before its publication. The article was preceded by article [I65], whose results led to my own proposal about the existence of new kind of representation of DNA in water [L5] and the recent article indeed suggests the existence of a new kind nano-scale represention of DNA besides electromagnetic representation of the code, which was also suggested for years ago by the group of Peter Gariaev [I53] and also in TGD framework [K52]. The article "DNA waves and water" (see `http://tinyurl.com/y8buy89k`) [L7] discusses TGD based explanation of the findings.

The claim of Montagnier's team is that the radiation generated by DNA affects water in such a way that it behaves as if it contained the actual DNA. A brief summary of experiment of Montagnier and collaborators is in order.

1. Two test tubes containing 100 bases long DNA fragments were studied. Both tubes were subjected to 7 Hz electromagnetic radiation. Earth's magnetic field was eliminated to prevent its possible interference (the cyclotron frequencies of Earth's magnetic field are in EEG range and one of the family secrets of biology and neuroscience since seventies is that cyclotron frequencies in magnetic fields have biological effects on vertebrate brain). The frequencies around 7 Hz correspond to cyclotron frequencies of some biologically important ions in the endogenous magnetic field of .2 Tesla explaining the findings. This field is 2/5 of the nominal value of the Earth's magnetic field.

2. What makes the situation so irritating for skeptics who have been laughing for decades for homeopathy and water memory is that the repeated dilution process used for the homeopathic remedies was applied to DNA in the recent case. The dilution containing no detectable amounts DNA (dilution factor was 10^{-12}) was placed in second test tube whereas the first test tube contained 100 bases long DNA in the original concentration.

3. After 16 to 18 hours both tubes were subjected to polymerase chain reaction (PCR), which builds DNA from its basic building bricks using DNA polymerase enzyme. What is so

irritating that DNA was generated also in the test tube containing the highly diluted water. Water seems to be able to cheat the polymerase by mimicking the presence of the actual DNA serving in the usual situation as a template for building copies of DNA. One could also speak about the analog quantum teleportation.

The model explaining remote replication would apply also to the findings of Montagnier. The essential elements would be sheets formed by flux tubes emerging from DNA crucial also in the model of DNA as quantum computer and nucleotide dependent resonance condition satisfied for each flux tube allowing DNA portion to active only similar DNA portion.

The findings of Montagnier demand that the genetic code is represented somehow by dark photons, presumably dark photon frequencies. How genetic code could be represented in terms of frequencies? The TGD based model of music harmony [L19] [K91] (see `http://tinyurl.com/zg3aaj7`) relies on the idea that 12-note scale is representable as a closed non-self-intersecting curve (Hamilton's cycle) at icosahedron having 12 vertices. The harmony assignable to a given Hamilton's cycle is characterized in terms of 3-chords assignable to the 20 faces (triangles) of the icosahedron once the 12-note scale is represented as a particular Hamilton's cycle.

Remarkably, the number of amino-acids is also 20! One indeed ends up with a model in which 20+20+20=60 DNA codons are represented by 3-chords for a triplet of harmonies defined by Hamilton's cycles predicting correctly the numbers of DNAs coding for a given amino-acid for vertebrate code. One must however assume that also tetrahedral harmony is present to get 64 DNA codons rather than only 60. TActually two variants of the code are predicted and altogether one obtains the standard 20 amino-acids plus two additional ones identified as Pyl and Sec known to be realized in living matter.

In music realization DNA codons can be represented as 3 dark photons or phonons with appropriate frequency ratios. This representation could explain the findings of Montagnier and Gariaev. There is also a connection with TGD inspired theory of consciousness. Music both expresses and induces emotions. The proposal is that the representation of DNA codons in terms of triplets of sounds or dark photons defines molecular level representation of emotions. There is large number of different harmonies and they could represent different moods.

2.13.4   Rupert Sheldrake

Rupert Sheldrake is very interesting thinker whose basic idea is that even genetic expression is more like a habit. Even the manner how crystallization takes place could be a habit. In TGD framework the 4-dimensional character of geometric existence and zero energy ontology in which quantum states are pairs of positive energy states assignable to the two light-like boundaries of causal diamonds conforms with Sheldrakes views (see the article "Sheldrake's Morphic Fields and TGD View about Quantum Biology" at `http://tinyurl.com/y79kxbua`).

The basic idea of Sheldrake that Nature would have habits just as we do is probably one of those aspects which generate most irritation in physicalists believing that Nature is governed by deterministic laws with classical determinism replaced with quantum statistical determinism. Sheldrake is one of those very few scientists able to see the reality rather than only the model of reality. Morphic resonance would make possible to establish the habits of Nature and the past would determine to high extent the present but on organic manner and in totally different sense as in the world of physicalist.

2.13.5   Seth Lloyd On Quantum Life

The notion of quantum biology is becoming accepted notion although Wikipedia contains still nothing about its most important application (photosynthesis). I can be proud that I have been a pioneer of quantum biology for about two decades. TGD remains still one of the very few theories leaving the realm of standard quantum theory and suggesting besides the new view about space-time a generalization of quantum theory involving in an essential manner quantum theory of consciousness based on the identification of quantum jump as moment of consciousness. The new view about quantum theory involves a refined view about quantum measurement based on Negentropy Maximization Principle (NMP) [K70] identified as the basic variational principle and zero energy ontology (ZEO) replacing ordinary standard energy ontology. The new view providing

new vision about the relationship between subjective time and geometric time, about the arrow of time, and about second law.

The hierarchy of Planck constants having as space-time correlate effective (or real -depending on interpretation) n-sheeted coverings of 8-D embedding space (or space-time) with $h_{eff} = nh$ defining the value of (effective) Planck constant. p-Adic physics as physics of cognition is essential part of theory and together with the hierarchy of Planck constants closely related to the notion of negentropic entanglement characterizing living matter. Negentropic entanglement is maximal involving two-particle case tge entanglement of n states characterized by $n \times n$ unit matrix with n identified in terms of h_{eff}. Also maximal m-particle entanglement with $1 < m \leq n$ is possible and one can write explicit formulas for the entangled states relating closely to the notion of exotic atom introduced earlier. The hierarchy of Planck constants as associated with dark matter so that dark matter is what makes living matter living in TGD Universe.

The concepts of many-sheeted space-time and topological field quantization imply that the concept of field body (magnetic body) becomes a crucial ew element in the understanding of living matter. Non-locality in even astrophysical scales becomes an essential piece of the description of living matter. Remote mental interactions making possible communication between biological and magnetic bodies become standard phenomena in living matter. The reconnection of magnetic flux tubes and phase transitions changing the value of h_{eff} and thus changing the length of magnetic flux tubes become a basic piece of biochemistry. Various macroscopic quantum phases such as dark electronic Cooper pairs and of protons and even ions as well as Bose-Einstein condensate of various dark bosonic objects with large value of h_{eff} are also central. They are associated with magnetic flux bodies (magnetic flux tubes).

TGD implies a new, still developing, view about metabolism. Magnetic body as a carrier of metabolic energy and negentropic entanglement (see **Fig. http://tgdtheory.fi/appfigures/ cat.jpg** or **Fig. ??** in the appendix of this book) allows to understand the deeper role of metabolism in a unified manner. The notion of high energy phosphate bond assigned to ATP is one of the poorly understood notions of biochemistry. As a matter fact, all basic biomolecules are carriers of metabolic energy liberated as they are broken down in catabolism. It is usually thought that the covalent bonds containing shared valence electron pair between atoms involved carries this energy and that covalent bond reduces to standard quantum theory. TGD challenges this belief: covalent bond could in TGD framework correspond to magnetic flux tube associated with the bond having considerably larger size than the distance between atoms: similar picture has already earlier emerged in the model of nuclei as strings with colored flux tubes connecting nucleons and having length scale much longer than nuclei [L3]: this model also explains [K72] the puzzling observation that protonic charge radius seems to be somewhat larger than predicted [C11].

The metabolic energy quantum would be associated with large h_{eff} valence electron pair being identifiable as cyclotron energy in endogenous magnetic field for which the pioneering experiments of Blackman [J28] suggests value $B_{end} = .2$ Gauss as the first guess.Of course, entire spectrum of values coming as power of two multiples of this field strength can be considered. This would require rather high value of h_{eff}/h of order 10^8. Reconnection of flux tubes would make possible to transfer these electron pairs between molecules: actually a piece of flux tube containing the electron pair would be transferred in the process. This view allows to unify the model of metabolism with the view of DNA-cell membrane system as topological quantum computer with DNA nucleotides and lipids (or molecules assigned with them) by flux tubes.

Seth Lloyd represents three examples about situations in which quantum biology seems to be a "must": photosynthesis, navigation of birds, and odour perception. Photosynthesis represents the strongest and most quantitative support for quantum biology. Navigation and odour perception suggest strongly quantum theory model but leave the details of the model open.

I have applied TGD to numerous situations during years and also discussed simple TGD inspired models for all these three phenomena. The following represents briefly the core of Lloyd's talk and comparison with TGD based views. I do not of course have access to the data basis and can represent only a general vision rather than detailed numerical models. I share Lloyd's belief that quantum models provide the only manner to understand the data although models as such are not final. The authors of course want to publish their work and therefore cannot introduce explicitly notions like high temperature super-conductivity, which I believe are crucial besides purely TGD based concepts. What is however good that the models start from data and just look how to explain the data in quantum approach. Data lead to assumptions, which are

not easy to defend in the framework of standard quantum theory. For instance, the presence of long-lived entangled pairs of electrons and electron and hole with wave functions possessing rather long coherence length and somehow isolated from entanglement destroying interactions with the external world emerge from the data. In TGD large value of h_{eff}/h and associated negentropic entangleement justifies these assumptions.

Photosynthesis

The incredible effectiveness of the first step of the photosynthesis after photon absorption [J67] is one of the key points of Lloyd in this talk (`http://tinyurl.com/yadbjx2x`). The organisms living deep under the surface of ocean are able to gather their metabolic energy using only the visible photons of black body radiation, whose typical photon energy is much lower than that of metabolic energy. In human eyes there is even mechanism preventing the detection of less than five photons at time.

The first step of photosynthesis after the capture of photon by harvesting antenna proteins has been a long standing mystery and here only quantum mechanical approach seems to provide the needed understanding. The light harvesting antenna proteins can be visualized as small disk like objects and are associated with a membrane like structure - so called thylakoid membrane similar to cell membrane. The absorption creates what is known as exciton - electron-hole pair, which is most naturally singlet. Photon has spin so that the exciton must have unit angular momentum. After its creation the electron of the exciton reaches by a random walk like process the reaction centre. From the reaction centre the process continues as a stepwise electron transfer process leading eventually to the chemical storage of the photon energy.

The capture of photon occurs with some probability and also the process continues from reaction centre only with probability of about 5 per cent. The process with which the electrons reaches the reaction centre is however amazingly effective: effectives is above 95 per cent. This is mysterious since fort the classical random walk for exciton between the chromophores the time is proportional to the square root of distance measured as number of neighboring chromophores along the path.

The quantum proposal is that exciton is spin singlet state - this minimizes the interactions with photons - and performs quantum (random) walk to the reaction centre. The model assumes only experimental data as input and all parameters are fixed. Temperature remains the variable parameter. One can consider two extreme situations. At low energy limit the random walks tends to be stuck since external perturbations (mostly thermal photons) inducing the random walk process are not effective enough and quantum walk becomes so slow so that the exciton decays before it reaches the reaction centre. At high energy limit the thermal perturbations destroy quantum coherence and classical random walk results so that the efficiency becomes essentially zero. There is a temperature range where the transfer efficiency is near unity and time for reaching the reaction centre relatively short. This range has as midpoint room temperature.

If I have understood correctly, the model accepts as experimental facts the rather long lifetime of the exciton - few nanoseconds. In quantum-computerish this assumption translates to the statement that exciton belongs to a de-coherence-free subspace so that external perturbations are not able to destroy the exciton too fast. Second assumption is that the exciton is de-localized over a ring ling like structure of size scale of 7 Angstroms (actually there are two rings of this kind, inner and outer and the wave function is assumed to be rotationally symmetric for the inner ring). This de-localization increases the probability of transfer to neighboring chromophore so that it is proportional to the square N^2 of the number N of chromophores rather than N. The technical term expressing this is concatenated quantum code.

Skeptic would probably claim that coherence and stability of coherence are the weak points of the model. In TGD framework the assumption that electron-hole pair is negentropically entangled would guarantee its long life time. The reason is that NMP [K70] favors negentropic entanglement. Negentropic entanglement corresponds to entanglement associated with n-sheeted effective covering of embedding space and n has interpretation in terms of effective Planck constant $h_{eff} = nh$. The naïve guess is that coherence scale for the wave function of exciton scales up by factor n or $\sqrt{n}$. This entanlgement need not have anything to do with spin but could relate to large $\hbar$.

I have earlier considered a slightly different proposal [K58]. Instead of exciton the negentropically entangled system would be Cooper pair of dark electrons. Note that the negentropic

entanglement need not relate to the spin but to the n-fold covering although it could be assigned with spin too in which case the state would be spin singlet. The motivation came from the fact that the transfer of electrons to the reaction centre takes as pairs (`http://tinyurl.com/ycrj3zqe`). The TGD inspired interpretation of electron pair would be as dark Cooper pair. Two electron pairs would come from the splitting of two water molecules to O_2, 4 protons and two electron pairs, and they would end up to P680 part of photosystem II (680 refers to maximally absorbed wavelength in nanometers) and from here to P680* as two pairs. This mechanism would require that the Cooper pairs absorbs the photon as single particle. In the case of dark Cooper pairs this might be naturally true. If this requires exchange of photon between the members of the pair, the rate for this process is of the order α^2 lower.

Avian navigation

Second topic discussed by Seth Lloyd is avian navigation (`http://tinyurl.com/zwdso`). The challenge is to understand how birds (and also fishes) are able to utilize Earth's magnetic field in order to find their way during migration. In some cases the magnetite in the beak of the bird guides the way along magnetic field lines by inducing magnetic force, and the process can be understood at least partially. Consciousness theorist could of course wonder why these animals find year after year their exact birth place.

Robins however represent an example not so easy to understand. There are three input facts:

1. Robins are able to detect the orientation of B_E but not its direction. They can also detect the angle between orientation and vertical to the Earth's surface and from this to deduce also the direction of B_E.

2. Blue or green light is necessary for the successful detection of the orientation.

3. Oscillating em field with frequency of order MHz makes the robins totally disoriented.

The only model that seems to be able to explain the findings is that long-lived entangled pairs of electrons are created by the photon provided their energy is high enough. For red light the energy is 2 eV and is not yet quite enough. This suggests that the electrons originate from a pair of molecules or atoms of single molecule. It is not known what the molecules in question could be. The electrons of the pair are spinning in the magnetic field and this is suggested to cause the decay of the pair and second member (why not both?) of the pair would contribute to a current giving eventually rise to nerve pulse pattern.

Entangled long-lived electron pair should be created. Long lifetime is the problem. The proposed mechanism brings in mind the TGD based variant for the light harvesting mechanism of photosynthesis. Universality suggests that long lived dark negentropically entangled Cooper pairs are generated in both cases so that light harvesting is in question in both cases. These pairs assignable to membrane structures in both cases in turn would generate a supra current giving eventually rise to a generation of nerve pulses in the case of navigation and to electron transfer process in the case of photosynthesis. If the same mechanism is involved in both cases, the extreme effectiveness of this light harvesting process could make it possible for the birds to navigate even in dark. Electron has cyclotron frequency of about 1.5 MHz in the Earth's magnetic field and this makes easy to understand why oscillation with this frequency (resonance) induces disorientation by forcing the spinning of the dark Cooper pairs.

Why the energy of photon creating the dark electron Cooper pair should correspond to visible light? Cyclotron energy scale for the ordinary value of Planck constant is extremely small and corresponds to frequency in MHz range. For visible photons the frequency by order of magnitude 10^8 higher. Does this correspond to the value of h_{eff}? Similar order of magnitude estimate follows from several premises. If the scaling of h by n corresponds roughly to the scaling of p-adic scale by $\sqrt{n}$, one would have roughly 10^{15}-fold (effective) covering of embedding space which looks rather science-fictive! For electrons this would imply size of order cell size if dark scale corresponds to the p-adic scale. If the electrons are originally in bound states with binding energy of order eV, the value of h_{eff} could be much lower.

I smell the quantum

Quantum detection of odours was the third topic in Lloyd's talk. For decades it was believed that odor perception is based on lock and key mechanism. Human has 387 odour receptors and this would be the number of smells too. It has however turned out that humans can discriminate between about 10^4 smells and Luca Turin and his wife have written a book giving a catalogue of all these smells. It is clear that lock key mechanism is correct but something else is needed in order to understand the spectrum of odors.

The key observation of Turin is that the smells seems to be not purely chemically determined but is different for molecules consisting of atoms differing only by the weight of nucleus and thus being chemically identical. Therefore the vibrational spectrum of the molecule, which is typically in infrared, seems to be important. The proposal of Turin is that the process of odour perception involves the tunnelling of the vibrating electron from odour molecule. This tunnelling can be assisted by absorption of phonon coming from the receptor with frequency which corresponds to fundamental vibrational frequency or its multiple. The model has been tested in several cases. The latest test described by Lloyd is the one in which hydrogen in some molecule is replaced with deuteron, which is twice as heavy so that the vibrational frequency is reduced by a factor $1/\sqrt{2}$. Fruit flies took the role of odour perceivers and it turned out that they easily discriminate between the molecules.

I have considered earlier a somewhat different quantum model for odour perception by starting from the pioneering experimental work of Callahan [I127], which led him to conclude that in the case of insects odour perception is "seeing" at infrared wavelengths. Infrared wavelengths correspond to vibrational energies for molecules so that this brings in the dependence on the square root of the inverse of the mass of the odorant and predicts that chemically identical molecules containing only different isotopes of atoms smell differently.Frequencies are same as in the model of Turin. Instead of phonons IR photons would play the key role serving as passwords exciting particular cyclotron state at particular magnetic tube. Similar mechanism could be at work in the case of ordinary vision.

2.13.6 Orch-Or Theory Of Penrose And Hameroff And New Experimental Findings About Microtubules

The latest news in quantum biology is the claim about corroboration of the Orch OR theory of Penrose Hameroff (see `http://tinyurl.com/ybgaeoeu`) [J6]. To my humble opinion the news suffer from rather heavy hyping. If the observation of the group lead by Anirban Bandyopadhyay about detection of quantum vibration in microtubule scale (their lengths vary up to 50 μm) can be replicated, one can speak about breakthrough in quantum consciousness. The results do not however prove Orch OR, which involves poorly defined vision about quantum gravitational description of state function reduction so that most predictions are just order of magnitude estimates relying on Uncertainty Principle.

The biological half of the theory relies on microtubules and for this side of the theory the claimed finding would of course be a victory. Indeed, there is a meeting in Amsterdam devoted to Orch OR theory of consciousness motivated by this finding (`http://tinyurl.com/zwayvl2`). Unfortunately, I could not find any article about the findings of Bandyopadhyay in web. I managed however to find two years old Youtube talk of Bandyopadhyay summarizing earlier experimental results supporting the vision about microtubules as macroscopic quantum systems (`http://tinyurl.com/ze366ny`) [J19] to be discussed below.

The findings reported in the talk give support for the general TGD inspired view about TQC and allow rather detailed model in the case of microtubules. The idea is that flux tubes form a 2-D coordinate grid consisting of parallel flux tubes in two different directions: the guess that they could consist of helical Fibonacci flux tubes and their mirror images is not however convincing. Crossing points would be associated with tubulins and the conformational state of tubulin could define a bit coding whether the braid strands defining coordinate lines are braided or not (swap or not). In this manner any bit pattern at microtubule defines a particular TQC program. If also conformations are quantum superposed, one has "quantum-quantum computation". It however seems that conformation change is irreversible chemical reaction [J63] so that this option is not feasible.

The TGD inspired modification of the proposal in terms of flux tube coordinate grids making possible TQC architectures with tubulin dimers defining bits defining in turn TQC program looks more plausible to me. Coordinate grids can be fixed on the basis of the experimental findings and there are 8 of them. The interpretation is in terms of different resolutions. The grids for A and B type lattices are related by 2π twist for the second end of the basic 13-unit for microtubule. An attractive interpretation for the resonance frequencies is in terms of phase transitions between A and B type lattices. If A type lattices can be generated only in phase transitions induced by AC stimulus at resonance frequencies, one could understand their experimental absence, which is strong objection against the Penrose-Hameroff model.

This would fit very nicely with the general vision about frequencies as passwords inducing not only directed attention but activities in target - also TQCs! The increase of Planck constant could be associated with the phase transition to A-phase making possible high T_c dark super-conductivity for which evidence is observed! One can even deduce estimates for $h_{eff}/h = n$ if one requires that AC photons have energy above thermal threshold: $n = h_{eff}/h = f_{visible}/f_A C$ would be the estimate. For bio-photon energies one would obtain something like $n \simeq 10^8 - 10^9$, which pops up in different contexts in TGD framework.

This picture generalizes in the fractal universe of TGD. One can form layers of 2-D coordinate grids and connect them by vertical flux tubes to obtain 3-D grid defining TQC. The brain is known to have grid-like architecture and neurons could by quantum computation produce bit/qubit defining swap or not/superposition of swap and not-swap for a larger scale TQC. One would have fractal of TQCs. One can even think 4-D grids in Euclidian space-time regions with 6 bits defining the swaps at each crossing point: could this have something to do with the genetic code?

A further idea is that 1-braid TQC generalize in a natural manner to 2-braid TQC in TGD framework (for 2-braids see [K56]. The knotting occurs for string world sheets defining the orbits of braid strands - say magnetic flux tubes idealized to strings. In the case of microtubules this option suggests itself: the emergence of MTs could have meant emergence of 2-braid TQC and the increase of abstraction level in the information processing. Note that 2-braiding is possible only if string worlds sheets "live" in 4-D space-time: for super strings living in higher-D space-time this is not possible.

In TGD Universe one could look at the situation also from the point of view of metabolism.

1. Dark particles quite generally have higher energies than ordinary particles. For instance, atomic bindings energies are scaled down like $1/h_{eff}^2$ and cyclotron energies scale like h_{eff}. The generation of dark particles with increased value of h_{eff} requires therefore energy identifiable as metabolic energy. The increase of h_{eff} creates quantum coherence in longer length scale in turn inducing coherence of living matter. $h_{eff}/h = n$ also serves as a kind of IQ for the system. The larger n is, the better ability the system has to generate negentropic entanglement.

2. In Bandyopadhyay's experiments AC voltage feeds metabolic energy. Microtubules of type A generated in the process are ordered in longer scale than microtubules of type B. In living matter this energy feed is due to the radiation generated by other parts of living system. Note that the basic objection abgainst Penrose-Hameroff theory is that in vitro only microbutules of type B are possible.

Penrose-Hameroff theory

Approximately two decades ago Penrose and Hameroff proposed a model that they called Orchestrated Objective Reduction (Orch OR) [J82]. Besides the highly speculative quantum gravity related ideas, the model assumes that microtubules are quantum coherent systems essential for consciousness. For the importance of microtubules one can find a lot of qualitative support. A I believe that microtubules are important for consciousness and I have developed ideas about the role of microtubules [K79]. Personally, however, I find it difficult to believe in the reduction of consciousness to microtubular level, but see microtubules as one particular layer in the hierarchy of conscious entities. Personally, I would prefer fractality over the naïve length scale reductionism.

Many objections [J63] against the biological feasibility of Orch OR (http://tinyurl.com/nx4vevv) [J82] have been raised. For the latest response of the authors to the criticism see [J81].

There are two basic challenges: one should formulate precisely what Orch OR really means and be able to identify the qubit.

1. The basic vision about quantum superposition of space-time geometries gives rise to consciousness as something analogous to quantum computation. State function reduction would thus reduce to a mechanism rather than being something irreducible. Most quantum physicists would disagree about this. The quantum superposed geometries would be protein conformations. Since there is no theory of quantum gravity, the proposal boils down to the ad hoc estimate for the time τ for Orch OR to take place claimed to be $\tau = \hbar/E_G$, where E_G is the difference of gravitational energies for the superposed geometries. The estimates favor nuclear scale 5 fm and one needs a coupling between nano-scale physics of electrons and physics nuclei and London forces are suggested to be responsible for this coupling. It deserved to be mentioned that the gravitational energy for a blog of water with radius around 10^{-4} meters - the size scale of large neuron - is about Planck mass so that gravitation and biology might relate. In my own proposal involving large gravitational Planck constant assigned to space-time sheets mediating gravitational interaction, Planck mass might serve as a threshold above which large values of Planck constant would emerge [K104, K81].

2. Concerning the identification of qubit there is a long list of suggestions. The superposition of tubulin conformations was one of the first proposals. Reimers [J63], who has criticized heavily Orch-OR proposal, reports that irreversible chemical reaction is responsible for selecting conformation so that quantum superpositions would not make sense. Conformational switching could however be involved with classical computational aspects of biological information processing and Hameroff has proposed before Orch OR that microtubules could act as classical cellular automatons.

   Also other proposals for qubit have been made. Quantum fluctuations generating London force between electric dipoles could somehow give rise to qubits. Also magnetic dipoles, nuclear spin, AC current flow, and synergistic modes have been mentioned. Also the identification of qubit as a helical conduction pathway has been proposed ("Oscillating London force dipoles in resonance rings in helical pathways through microtubule lattices"). It is difficult to imagine what the two superposed states defining qubit would be. For instance, could qubit correspond to electron current running in two different directions and is quantum superposition possible at criticality for a phase transition inducing the change of the current direction? For this option the information storage capacity of microtubule would be rather modest. In also difficult to see the claimed connection with topological quantum computation since braiding gives rise to entanglement between states at the ends of the braids.

Orch OR proposal involves several interesting ideas probably relevant for quantum consciousness.

1. Aromatic rings have probably some deep role in quantum consciousness. For instance, most psychoactive biomolecules and also DNA and three amino-acids contain them. Hameroff and Penrose trace this role to London force between aromatic rings and quantum fluctuations making them qubits. I am unable to imagine what the exact proposal is. In any case, what is known is that electrons at aromatic rings are de-localized.

   Comment: My own humble proposal is that electrons could be further de-localised at magnetic flux tubes in longer scales and make cyclotron BE condensates of dark electrons or their Cooper pairs possible. They would make possible the coupling between receptor-information molecule complex and magnetic bodies at various levels of hierarchy. Hierarchy of Planck constants and negentropic entanglement suggests the existence of a new kind of state consisting of electrons (that is fermions) but analogous to Bose-Einstein condensate.

2. The idea about insulation provided by hydrophobic pockets of proteins against fluctuations destroying quantum coherence is nice and it would be natural to put aromatic rings into these pockets.

3. The needed long value of Orch OR de-coherence time τ (originally assumed to correspond to 40 Hz thalamocortical resonance frequency) is one of the problems of Orc OR and the recent

discovery of EEG like oscillations in kHz range [J70] is claimed to make the situation more tolerable.

Comment: Fractal hierarchy of EEGs mediating communications between parts of biological body and corresponding magnetic body is basic prediction of TGD and the observation seems to provide evidence for this prediction.

4. Reimers *et al* challenges [J64] also Fröhlic Bose-Einstein condensation [J80] and claims that according to his own simulations the resulting state is extremely incoherent [J64]. There are however models which give Bose-Einstein condensation [J18] and the in [J19] the experimental findings about assembly of microtubules are interpreted as Fröhlic condensation. The frequency inducing the condensation would be however 3 orders of magnitude lower than predicted by Fröhlich.

There is a further puzzling result (`http://tinyurl.com/y7f2r93o`) [J56] in conflict with the assumption of Orch OR that brain microtubules are dominantly so-called A-type tubules. Brain microtubules re-assembled in vitro form lattices of type B and for them the lattice must have surface discontinuities. This makes sense for microtubules which are partially fused together as in the structures consisting of cylinder whose surface is formed by 9 units consisting of 3 microtubules glued together along their sides. This would not allow Fibonacci helices proposed by Penrose and Hameroff to serve as conducting pathways defining the analogs of braid strands in their model for microtubule as topological quantum computer (TQC) unless one is ready to give up helical symmetry. One way out of the difficulty would be that vitro results do not hold in vivo but Kikkawa *et al* has shown that all in vivo microtubules have lattice of type B (`http://tinyurl.com/ybnxymuw`) [J50].

The above mentioned article concludes that only the lattice B is realized in nature. This lattice does not possess helical symmetry. After each full turn along sequence α or β tubulin sequence there is a shift as the figure 2 of the article demonstrates: this discontinuity is called seam in the article. Furthermore, these helices can be said to have periodicity 5. The helix-like curve satisfies the condition $z = 4a\phi/2\pi$ and the nth tubulins along vertical is located at $z(n) = na$, a the size of the tubulin. For $\phi = 2\pi$ one has $\Delta z = a$ rather $\Delta z = 0$ as figure 2 of the article shows. This discontinuity could have some important biological meaning.

Hameroff, Nip, Porter, and Tuszynski have an article about microtubules as topological quantum computation written in 2002 [J47]. They do not give any justification for why the conduction pathways should correspond to Fibonacci numbers but the article by Hameroff represents evidence that the important certain amino-acids crucial for consciousness inside tubulin molecules are located along the Fibonacci conduction pathways (`http://tinyurl.com/yb5odlmn`) [J47].

2011 Hameroff and Penrose considered the possibility that microtubules could perform topological quantum computation. The proposal of Penrose and Hameroff (`http://tinyurl.com/yb5odlmn`) [J47] assumes realization of braiding in terms of helical braids strands assignable to A-type microtubules (which according to experimenters do not exist in brain and - as it seems - in living matter in general). In the simplest realization the strands are parallel to each other and have horizontal periodicity characterized by 13 tubules. Also Fibonacci pathways with horizontal periodicity of 3, 5, and 8 are Fibonacci pathways. The strands with different periodicities can intersect and can therefore be braided. One can also construct left- and right handed variants of the strands and left- and right-handed strands intersect periodically with a period of 13. The experiments discussed in [J19] however suggest a different kind of braidings.

In the intersection points braiding (swap) operation could be realized meaning that first strand goes either over or below the second one. Gupta and Hameroff suggests that MAPs are responsible for this kind of swap and thus define the fundamental quantum gates for TQC (`http://tinyurl.com/ycohz259`) [J79]. Of course, also more complex gates can be imagined but swap is enough to build universal TQC. Official biology assigns to MAP many other functions associated with MAPs but also this function can be imagined. Penrose and Hameroff have also considered the possibility that topological qubits are represented in terms of quantum superpositions of helical pathways with 13-periodicity characterized by the gap between neighboring pathways.

The identification of Bandyopadhyay for conduction pathways

In his Youtube talk Anirban Bandyopadhyay (`http://tinyurl.com/ze366ny`) [J19] discussed an identification of conduction pathways different from that of Penrose and Hameroff. In [J75] Gosh, Sahu, and Bandyopadhyay argue for evidence for massive global synchronization in brain and claim that experimental findings support the Penrose-Hameroff theory. In the article "Atomic water channel controlling remarkable properties of a single brain microtubule: correlating single protein to its supramolecular assembly" [J65] it is reported that ordered water inside microtubule is necessary for the conduction inside microtubule. According to the same article the tubulins inside microtubule has same energy levels in chemical energy range as isolated tubulins which suggests that the mechanism binding tubulins to form MT is not chemical. In the article "Multi-level memory-switching properties of a single brain microtubule" [J66] it is reported that the hysteresis curve for current along MT as function of voltage is ideal square curve meaning that there is no dissipation involved with the change of the current direction. This would make MT as an ideal memory device. Whether Penrose/Hameroff have in mind the use of current direction as qubit remains unclear. In video talk Bandyopadhyay refers also to these results.

I consider only the general proposal discussed in video lecture here: the Youtube representation gives concrete illustrations of conduction pathways.

1. It is assumed that there are two kinds of hexagonal tubulin lattices labelled as A and B. As found there is strong evidence that A-type tubules do not exist stably. For both types the tubulin dimers defining dipoles are nearly axial and define candidates for conduction paths with winding periodicity of 13 tubulin dimers. For B type one has rows made of α or β type tubulins along with α and β have effective periodicity of five if one accepts discontinuity at after 2π rotation. One might think that this dictates the choice of the candidates for the conduction paths to consist of sequences of $\alpha-\beta$ dimers: for these sequences are along the microtubule. If hops occur between α and β this assumption is natural. The proposed pathways are however more general and - as it seems to me - based on rather ad hoc mathematical rule.

2. The notion of helical conduction pathway is the starting point. For B-type tubules this notion must be modified. Presumably the criterion for what it is to be a helical pathway is that they are straight-lines connecting nearest neighbors to each other- this is natural if conduction is identified as hopping between neighboring tubulin molecules. The position of each pathway represented by a value of discrete dynamical variable replacing spin as representation of qubit -essentially the angle $\phi = n \times 2\pi/13$ is in question. There are 13 different values for ϕ. For A-type conducting pathways the condition that one has $\alpha - \beta$ sequence very probably gives the claimed pathways with periodicity 13. One can ask whether the pathways of type A are obtained by twisting the pathways of type B at the second end by 2π and whether living systems could be able to perform this twist to achieve phase transition between two states of the microtubule.

3. Instead of single pathway one considers groups of parallel pathways consisting of translates of a fixed pathway with a fixed gap $\Delta\Phi_{gap} = n_{gap}2\pi/13$ along the circumference of microtubule. I failed to understand the motivation for this: maybe the idea is that the additional degree of freedom makes possible the analog of spin degree of freedom as angular position of the pathway. One could also consider the possibility that the translates of a pathway define a braid: this braid would be however trivial since the pathways are parallel. If I have understood correctly, topological qubits would be represented as quantum superpositions of helical conduction pathways with same gap $\Delta\phi = n_{gap} \times 2\pi/13$ between neighboring pathways. This is not what TGD suggests.

4. By $n = 13$ modulo arithmetics it can that the series of pathways with $n = kn_{gap} \ mod \ 13$, $k = 1, 2, ...$ generates additional gaps. One says that the decomposition occurs. The addition of translated parallel pathways can also lead to a pair of pathways with $n_{gap} = 0$ or $n_{gap} = 1$ in which case pathways overlap or touch. This is not allowed. What this means physically is unclear to me. One could also avoid touching simply by allowing only the translates to be such that $kn_{gap} \leq 13$ holds true: even weaker condition can guarantee this.

Consider first what one obtains for A-type microtubules.

1. The construction rule gives for $n_{gap} \in 1, 2, 3, 4, 6, 12$ many secondary gaps, in particular $n_{gap,new} = 1$ so that "don't touch" rule is violated. For $n_{gap} \in \{5, 7, 8, 9, 10, 11, 13\}$ only 1 or one secondary gap or no secondary gap is obtained. The decompositions of primary gaps are

$$5 \to (5,3) \ , \quad 7 \to (7,6) \ , \quad 8 \to (8,5) \ , \quad 9 \to (9,4) \ , \quad 10 \to (10,3) \ , \quad 11 \to (11,2) \ , \quad 13 \to 13 \ .$$

2. One can form from these collections of parallel pathways more complex collections as unions. Only unions for which "don't touch" rule is satisfied. This leaves for A-type microtubules 4 groups of pathways characterized by four values of n_{gap} each. The 4 groups of 4 of n_{gap} values which can co-exist without breaking teh basic rule are

$$\begin{matrix} (8, & 5, & 10, & 13) \\ (7, & 9, & 11, & 13) \\ (5, & 7, & 10, & 13) \\ (5, & 7, & 9, & 13) \end{matrix} \tag{2.13.1}$$

Here only the generating gaps are listed. For instance, the $(8, 5, 10, 13)$ decomposes to $(8, 5, 3, 10, 13)$.

3. There is a problem: these parallel pathways do not have intersections and therefore cannot form braids unless also their mirror images are allowed or one introduces additional group of pathways, which could be called transversal.

4. One does not obtain Fibonacci conduction pathways with periodicities 3, 5, 8 for *A*-types microtubules suggested by Penrose and Hameroff. One could argue that since the periodicity as winding number is a topological characteristics, the correct identification should give all winding numbers or at least those which are Fibonacci numbers in case A-type microtubules.

What about B-type microtubules?

1. For B-type microtubules one obtains 4 pathways, one of them parallel to the microtubule and the remaining three with periodicity 7. Only the gaps 2, 3, 4 are allowed by the "don't touch" rule. 2 and 3 do not decompose and 4 decomposes to $(4, 2)$ so that 2 and 4 can co-exist.

2. For the axial pathway X there is no restriction to the values of n_{gap} unless one just assumes $n_{gap} = 2$ as in the illustration of slides. It is argued that together A and B-type pathways cover the entire series. I failed to understand what this means: in any case, the primary gap number $n_{gap} = 12$ is missing and I find difficult to understand what complementarity could mean.

3. The 3 pathways 2, 3, 4 are parallel and cannot intersect each other but they can intersect the axial pathways called X so that braiding is possible. For X type pathways conduction would take place along sequence of $\alpha - \beta$ pairs.

4. For A-option one obtains only periodicity 13 and for B option periodicity 7 for primary gaps 2, 3, 4 and periodicity 1 for the line parallel to microtubule with periodicity 1.

Bandyopahyay emphasizes that A-type pathways are ideal for TQC whereas B-type pathways are ideal for communications. I did not understand the argument. Certainly this requires that a phase transition from B to A can take place.

The transitions reported to occur as the microtubule is excited at certain resonance frequencies, would in this picture correspond to transitions between different groups rather than excitation of single pathway. The number of resonance frequencies is reported to be 8. If there are n pathways

all possible transitions would give $n(n+1)/2$ resonance frequencies: this number cannot be equal to 8 unless some frequencies are degenerate. It would seem that more plausible interpretation is in terms of excitation of a physical state assignable to given pathway or group of its parallel translates rather than between groups of them.

Microtubules from TGD point of view

In TGD framework microtubules are especially interesting from the point of view of TQC - both for 1- and 2-braids and MTs might represent an evolutionary step in which 1-braid TQCs were extended to 2-braid TQCs.

   1. What does one mean with TQC?

   I ended up with my own proposal about TGD Universe as topological quantum computer (TQC) around 2002 [K6] with inspiration coming from New Scientist article [C2] - at the same time Hameroff has proposed the idea about conducting pathways as braids. By looking at old blog articles I learned that I have developed the vision about DNA as TQC during 2007 [K5, K119].

   The proposal is that the braiding of magnetic flux tubes associated with the magnetic bodies of biomolecules - and probably also much larger structures - makes possible TQC like activities basic aspect of living systems. For instance, braids connecting DNA and nuclear and cellular membranes could make possible automatic construction of memories as space-like braidings of magnetic flux tubes induced by time like braiding generated by the liquid flow around cell and nuclear membrane [K5]. Also microtubules could be connected to axons by flux tubes and similar mechanism could be at work. A universal representation of memories could be in question and couple microtubules directly to the neural activities.

   It is essential that the second of each braid is free to move so that temporal braiding patterns are generated and induce spatial braiding patterns (dance metaphor helps to visualize this [K5]). Second essential point is that the qubits reside at the ends of braid strands. This is why the statement of Penrose and Hameroff that conduction pathway defines a qubit in some manner - say in terms of current direction - does not make sense in standard TQC paradigm. In the following I shall propose that the statement can be made to make sense if one considers generalization of TQC involving 2-braids instead of 1-braids so that 2-D objects get "knotted" instead of 1-D objects [K56].

   The braiding induced by say 2-D flow of lipids would still be passive generation of memories but one could consider also genuine quantum computation like activities in which the braiding defining the TQC program is constructed in a controlled manner. For instance, one could associate to microtubular surface highly regular "pre-braidings" involving crossings of magnetic flux tubes for which basic braiding operation (swap) between neighboring braid strands could be controlled by the tubulin molecule associated with the crossing. Swap could be determined by the tubulin conformation in the crossing defining a classical bit so that classical computer program expressible as cylindrical surface decorated with bits would code TQC program. In this manner coupling of the events at cell membrane to microtubular quantum cognition would be achieved.

   What one exactly means with topological quantum computation (TQC) is not at all obvious and one can consider several variants of it in TGD framework.

1. Zero energy ontology (ZEO) leads to the notion of unitary U-matrix and orthonormal basis of M-matrices which are "square roots" of density matrices expressible as products of hermitian matrix and unitary S-matrix depending on the size scale n of CD in very simple manner: $S(n) = S^n$, where S is the S-matrix for the minimal sized CD.

   M-matrices define time-like entanglement coefficients between the positive and negative energy states at the opposite boundaries of causal diamond (CD). For braid strands along light-like 3-surfaces defining string ends one obtains entanglement between fermions at the ends of strands. Since the entanglement matrix is unitary it defines density matrix which is sum over projection operator acting as identity matrices and state function reduction yields a negentropically entangled state carrying information. One can pose additional conditions on space-time like negentropic entanglement (NE) (see **Fig. http://tgdtheory.fi/ appfigures/cat.jpg** or **Fig. ??** in the appendix of this book) and ends up with a highly

unique form of entanglement coefficients from the condition that any splitting of the system to two parts defines negentropic entanglement [K70].

Under rather natural assumptions S-matrix reduces to a unitary representation of scaling of causal diamond (CD) [K75]. U-matrix elements between M-matrices for various CDs are proportional to the inner products $Tr[S^{-n_1} \circ H^i H^j \circ S^{n_2} \lambda]$, where λ represents unitarily the discrete Lorentz boost relating the moduli of the active boundary of CD and H^i form an orthonormal basis of Hermitian square roots of density matrices. $\circ$ tells that S acts at the active boundary of CD only. I turns out possible to construct a general representation for the U-matrix reducing its construction to that of S-matrix.

2. In absence of degeneracy giving rise to negentropic entanglement one would have ordinary entanglement and ordinary quantum measurement theory applies. The outcome of TQC would be statistically determined from state function reductions for large enough number of sub-CDs of given CD. It would be coded by quantum classical correspondence (QCC) to the parameters characterizing classical fields inside CD (frequencies, wave numbers, ...). EEG patterns would be one particular representation of this kind.

3. The sequence of state function reductions defining sub-self as mental image would correspond to the reading of Akashic records as kind of TQC. TQC would represent "Akashic records" and by NMP Universe would be building increasing library of Akashic records. This might provide a general mechanism of term memory.

4. Also a generalization of ordinary 1-braid TQC to 2-braid TQC is suggestive. 1-D braid strands define braiding of orbits of point like particles in 3-D space space-time - say light-like 3-surface. In TGD framework the 1-D braid strands correspond to the boundaries of 2-D string world sheets and the evolution of string world sheets corresponds to 2-braid in space-time. One obtains a generalization of 1-braid TQC to 2-braid TQC in which knotting occurs for 2-D string world sheets of 4-D space-time rather than 1-D strings of 3-D space.

Qubits at the ends of time-like braid strand are replaced with quantum states at space-like braid strands defining ends of string world sheet and TQC corresponds to a time evolution in which the 2-knotting of braid strands changes. The first basic operation is what Alexander the Great did for the knot - the breaking of 1-knot temporarily. What happens is following: if braid strand A goes over B before the moment of breaking, it goes below B after it. This is however not the only possible operation: also reconnection - basic operation for magnetic flux tubes - can take place: the braids strands AB and CD are replaced with AD and CB. These operations define standard vertices in closed string model. The sequence of these operations defines 2-braiding and one can assign to it a generalization of 1-braid TQC to 2-braid TQC. 2-braid TQC is not possible in super string models since strings are embedding in space-time having dimension higher than $D = 4$.

The quantum states of braids strand would define qudits. In TGD qupits representable as superposition of p^N states, p prime, are of special interest in TGD framework.

2. Could MTs lead from 1-braid TQCs to 2-braid TQCs?

What can one say about the situation concerning microtubules in TGD framework? Since I am not a professional biologist, I can imagine rather freely.

Consider first TQC in the standard sense, that is for 1-braids.

1. The obvious question concerns the nature of the braid strands (conduction pathways in the terminology of Penrose and Hameroff) and here standard physics cannot provide much insight. A natural TGD based identification would be in terms of magnetic flux tubes carrying dark electrons or even better, their Cooper pairs forming currents running along the microtubule. This would predict that microtubules act as super-conductor like systems. The basic aspect of this kind of system is resistance which does not depend on the length of the wire since the resistance is determined by what happens at the ends of the wire where electron current enters or leaves the wire - now flux tube. For ordinary superconductors the resistance involves term which does not depend on temperature. Also now one might expect that the resistance has similar behavior.

The states of Bose-Einstein condensate at the braid strand cannot defined the qubits in ordinary 1-braid TQC for which the states reside at the ends of braid matter. The flux tubes should have ends - at least effectively. The ends should carry quantum numbers defining the qubits. The effective end would correspond to wormhole throat of a wormhole contact at which the magnetic flux flows to another space-time sheet. Quite generally, the flux tubes would be closed structures: for instance, elementary particles correspond to two-sheeted flux tubes having two wormhole contacts as "ends".

2. Maybe the tubulin at the crossing point could induce swap or not depending on its state. Tubulin dimers possess two different configurations and the original proposal of Hameroff was that these configurations correspond to two values of bit. The bit represented as a tubulin conformation would tell whether the left-handed strand runs above or below the right-handed strand at the crossing. The braiding would have representation as a 2-dimensional cylinder with points representing classical bits determining the TQC program. Classical computing and quantum computing would couple together. If tubulin conformations could form quantum superpositions, one would have "quantum-quantum-computation". According to [J63], the process inducing the change of tubulin conformation is chemical irreversible process so that this option does not seem to be possible.

3. The swap at the crossing point for certain value of time would be determined by the state of the tubulin at the crossing at particular moment. At each moment the braiding pattern for braids connecting microtubule ends would determine the TQC program in terms of entanglement matrices proportional to unitary matrices. What is important is that unitary matrix between the states at the ends of braid gives rise to NE with entanglement probabilities forming a matrix proportional to unit matrix. The NE alone could be in principle source of conscious information obtained during sequence of state function reductions at a fixed boundary of CD defining self. These states or selves would define what I have called "Akashic records" responsible for memory storage as quantum invariants.

What is new that a generalization of TQC based on 2-braids defined by string world sheets can be imagined. The idealization of time evolutions of magnetic flux tubes can be idealized as string world sheets so that magnetic flux tubes would become key players also in 2-braid TQC. The transition from DNA as TQC to MT as TQC could correspond to the replacement of 1-braids with 2-braids. The quantum states of 2-braid TQC would corresponding unhalting 1-braid TQCs. This would represent a step leading to a higher abstraction level and could play a fundamental role in evolution in accordance with the role of emergence of microtubules in ontogeny.

1. The states of braid strands could define qubits for TQC based on 2-braids defined by string world sheets assignable to time evolutions of flux tubes idealized as strings.

   The spin direction of cyclotron Bose-Einstein condensate defines one candidate for qubit. The direction of DC current along braid strand could also define qubit. If the system is ideal Josephson junction then a constant voltage should however gives rise to an oscillating current. The presence of resistances at the ends of the flux tubes is expected to give rise to the standard form of Ohm's law in average sense.

2. The hysteresis curve for the micro tubular current I as function of voltage V between the ends of microtubule is reported to be square [J66] so that the phase transition changing the current direction could be quantum phase transition at criticality and make possible qubits as superpositions of both current directions near criticality for the current flip. TQC would halt when the voltage is changed so that it is not in the critical region anymore.

3. For magnetic flux tubes the vertex changing swap for 1-braid corresponds to reconnection, which would therefore find a new application in TGD inspired biology. I have earlier proposed that the ATP-ADP transformation generates reconnection but failed to realize that the interpretation could be in terms of 2-braid TQC. Energy metabolism as a continual occurrence ADP→ATP and its reversal could be also a direct signature of 2-braid TQC. The spatio-temporal pattern of ADP↔ ATP transformations would reveal the TQC program code.

4. The change of the conformation of tubulin molecule would induce a swap. The reconnection of flux tubes -perhaps also induced by a change in the conformation of tubulin molecule - is also possible. The TQC program for 2-braids would be coded by the temporal history of changes of tubulin conformations represented in terms of bits. Chemistry would be used to write TQC programs. 2-braid TQC could be seen as sequence of 1-braid TQCs, which need not halt.

Admittedly, the model involves several new physics elements, which skeptic with Occam's razor could use to debunk the approach: dark matter hierarchy represented as hierarchy of effective Planck constants, the motion of magnetic body implied by the TGD based geometrization of classical fields and new view about space-time, and the notion of NE and Negentropy Maximization Principle [K70] defining the variational principle of TGD inspired theory of consciousness. These new elements are not however ad hoc assumptions but basic pillars of quantum TGD.

3. Identification of conduction pathways

Consider next the detailed identification of the conduction pathways assumed to correspond to a grid formed by flux tubes.

The interpretation of Bandyopadhyay has some problematic aspects. The proposed parallel strands do not intersect and cannot therefore define braid. The transitions to which the resonance frequencies are assigned, are not identified. No comment is represented concerning the problem that A-type microtubules have not been observed experimentally. From these problematic aspects it takes some time to end up with TGD based vision about the situation.

1. In TGD framework it is natural to regard the pathways of A-type microtubules as obtained by 2π twist for the "upper" end of B-type pathways which are of type X and possess the primary gap numbers allowed for A-type groups: recall that this gives 4 groups of four primary gaps. The pathways obtained from the transversal pathways of B-type microtubules by 2π twist define an excellent candidate for the complementary pathways needed to obtain crossings and braiding.

   What looks like a problem is that the twist for the 3 groups of 7-periodic pathways would produce two 7-periodic pathways per 13-unit, which corresponds to 14 rather than 13 tubulins rather per basic unit. The only explanation is that the discontinuity disappears and implies that there one has 13 tubulins per single structural unit of Q-type tubule.

2. If one excludes the decomposable pathways with $n_{gap} = 4$, the twists of 2 and 3 groups would define transverse pathways for A-type microtubules. Altogether 8 different coordinate grids formed by the pathways - now magnetic flux tubes - would be obtained. The 8 resonance frequencies would correspond to the phase transitions $A \leftrightarrow B$ induced by $\pm 2\pi$ twist for the "upper" end of the basic unit.

3. In TGD framework the most natural explanation for why A type tubules are ideal for TQC is that they correspond to a large value of h_{eff}, and the phase transition increases the value of h_{eff} and makes superconductivity and TQC possible for A type tubules. Unitary S-matrix characterizing TQC defines entanglement probabilities which are identical so that NE is in question. NE is very closely related to large value of $h_{eff}/b = n$: n corresponds to the number of entangled states in the simplest situation.

4. One can estimate the value of h_{eff} if the AC radiation inducing the phase transition corresponds to dark photons with energy which is above thermal energy. For the energy $E \simeq 2$ eV of visible photons this would give for 8 MHz frequency $n = h_{eff}/h \simeq 6 \times 10^7$. For IR frequencies above thermal threshold which corresponds to the energy $E \simeq .05eV$ assignable to resting potential, one would have $n = h_{eff}/h = 10^5 - 10^6$.

   Corresponding p-adic length scales giving estimates for the length scales of flux tubes would scale like $n^{1/2}$. For B-type microtubules the p-adic length scale would be naturally 5×4 nm corresponding to 5-periodicity and 4 nm length diameter for single tubulin. For A-type microtubules corresponding scale would be by factor 10^3 longer for IR frequencies: upper bound would give 20 μm. The length of microtubules obtained in experiments ranges from 2μ to 25 μm so that the estimate seems to make sense.

4. Could frequency hierarchy correspond to a p-adic hierarchy of magnetic flux tubes?

The hierarchy of frequency scales kHz, MHz, and GHz could correspond to cyclotron frequencies for electron and perhaps also proton. In particular, the crucial role of water in making conductivity possible suggests that protonic cyclotron B-E condensate is important in the water core of MT at least but possibly also in longer length scales.

1. TGD allows magnetic monopole fluxes for flux tubes: in this case the cross section of the flux tube would be closed 2-D surface (sphere) rather than disk, and no current rotating around the tube would be needed to create the magnetic flux. This kind of flux tubes could explain the presence of magnetic fields in cosmic scales: in Maxwellian cosmology they are impossible in early cosmology because the needed currents are to possible. This kind of fluxes might be associated with super-conductors and even permanent magnets. The unit of magnetic flux $\Phi = \int eBdS$ is $h/2$ for a disk cross section. For spherical cross section of monopole flux tube the flux is $\Phi = \oint eBdS$ and unit is $2h$ that is 4 times larger. This could serve as a test for whether one has monopole flux or standard flux.

2. I have proposed that constant endogenous magnetic field $B_{end} = .2$ Gauss$= .2 \times 10^{-4}$ Tesla could explain the effects of ELF radiation to vertebrate brain as resulting from cyclotron transitions of large h_{eff} B-E condensate. The recently updated model replaces cyclotron transitions with phase transitions scaling the value of p-adic prime and thus the value of the magnetic field. The model yields essentially the same predictions as the earlier model. The phase transition scales down the radius of the flux tube characterized by p-adic length scale $L(k) \simeq 2^{(k-151)/2} \times L(151)$, $L(151) \simeq 10$ nm by a power of two: the increase in cyclotron energy due to the reduction of flux tube radius is in good approximation $ne(B_f - B_i)/m = neB_f(1 - 2^k) \simeq neB_f$, where B_f is the field strength for the compressed magnetic flux tube.

3. For electron in endogenous magnetic field of .2 Gauss cyclotron frequency is $f_e \simeq .5$ MHz: for proton one has $f_p \simeq 300$ Hz (note that the ratio of cyclotron frequencies of electron and proton is given by the mass ratio $m_p/me \simeq 1843 \sim 2^{11}$). The reported resonance frequency is $f \simeq 8$ MHz, which is 2^4 times higher than f_e. This suggests that the irradiation induces p-adic phase transition of flux tubes contracting them by a factor $1/2$ and increasing field strength by a factor 4. This would mean that the p-adic length scale is reduced from $L(k)$ to $L(k - 4)$. The possibility of this interpretation yields support for the p-adic length scale hypothesis.

4. Purely number theoretic considerations predict that in biologically interesting length scale range ranging from 10 nm to 2.5 μm there are four p-adic length scales which correspond to Gaussian Mersenne primes $M_{G,n} = (1 + i)^n - 1$, $n = 151, 157, 163, 167$. One could speak of a number theoretic miracle. It is easy to see that the transition induced by 8 MHz radiation could correspond to the transition $k = 167 \to 163$ for electron. This gives strong support for the fundamental role of these Mersenne scales.

   First, B_{end} corresponds to magnetic length of $L_B = \sqrt{\hbar/eB} = 5.7$ μm not far from the p-adic length scale $L(169)$ is $L(169) \simeq 5.1$ μm. L_B would give flux quantum $h/2$. The problem is that this scale is by a factor 2 longer than the Mersenne scale $L(167)$. Situation changes if the flux is monopole flux for flux tube with spherical rather than disk-like cross section. By previous argument the flux quantization would be obtained for a sphere with radius given by the p-adic length scale $L(167)$. One would obtain Mersenne scale and the transition $L(k) \to L(k - 4)$ would correspond to $k = 167 \to k = 163$. Proton cyclotron frequency would be scaled up in this transition to 4.8 kHz and it would be natural to identify frequencies in kHz frequencies as harmonics of f_p.

5. The scaling $k \to k - 11$ would transform $f_e = .5$ MHz to $f_e = 1$ GHz. The p-adic scale would become $k = 156$. $k = 157$ would have been more attractive outcome. $L(156) \simeq 57.6$ nm looks too large to be radius for a magnetic flux tube assignable to the MT strand of thickness of order 4 nm. I would more naturally correspond to the length scale defined by a strand of 13 tubulins.

6. Microtubule strand corresponds to length scale 4 nm which suggests that p-adic length scale $L(149)$ assignable to lipid layer of cell membrane characterizes the flux tubes defining the coordinate grid at MT surface. GHz frequency is assigned with the order water in the interior of MT $L(145) \simeq 1.25$ nm seems to be a good candidate for the corresponding p-adic length scale. $f_p = 1.35$ GHz frequency is obtained if flux the transition is $k = 167 \rightarrow 145$.

7. An attractive possibility is that the flux tubes in the interior of MT contain dark proton sequences defining the dark nuclei with single dark proton with large value of Planck constant h_{eff} with size scale of single DNA codon. The amazing prediction of the model of dark nucleon is that the counterparts for the DNA, RNA, amino-acids and even tRNA are obtained and vertebrate genetic code can be realized as a natural correspondence between these states [K53, L3]. One can imagine the possibility that the dark genetic codes inside MT and connected by radial magnetic flux tubes to the codons at the braid strands at the surface of MT.

5. About B-type lattice

Some TGD- and computer science inspired comments on B-type lattice are in order.

1. B-type lattice is discontinuous along vertical line. There is a horizontal pair of α and β tubulin monomers at discontinuity and here α (β) tubulins have 3 instead of 2 nearest neighbour β (α) tubulins. Could the possible flux tubes connecting microtubule to the axonal membrane and making possible to receive sensory input begin here? The flux tube pair parallel to this line brings in mind DNA double strand. The α- or β-sequences with vertical 5-periodicity would be discontinuous after full turn: the shift in vertical direction would be 5 tubulin units but single turn of the helical path would correspond to a vertical shift of 4 tubulin units only.

2. The discontinuity suggests that the tubulin consists of pieces of 13-units maybe defining a sequences of 13 binary digits as code words - kind of bytes - in turn defining the classical computer code giving rise to TQC code.

3. A second interesting aspect is the 7-periodicity of transversal pathways in axial direction. One of the TGD inspired models for genetic code [K52] interprets 64 genetic codons as a subset of 127 element space consisting of $2^7 - 1$ elements identified as a subset set of mutually consistent logical statements of 7-bit algebra so that the negation of the statement cannot belong to the set.

Statements would be analogous to axioms of mathematical system being identically true. One statement is non-realizable: in case of set theoretic realization it would be naturally empty set. If statements are realized as spin excitations of ferromagnet then absence of spin excitations would correspond to the non-realizable statement. One could also argue that only communicable statements are possible. Communication of the state could be defined as radiation generated by the transition from the ground state to a multiply excited state. If there is no change (ground state goes to ground state), the statement is not communicable. Could 7-bit sequences be restricted by the condition that they represent identically true statements? This condition would make possible error correction mechanism analogous to parity bit.

6. Could DNA sequences code for TQC programs?

One also ends up with a rather crazy idea about possible interpretation of genetic code.

1. If one piles up 2-D TQC: s one obtains 3-D 1-braid TQC. In crossings one must have 3 bits to specify whether to swap or not since there are three planes for TQC and 3 pairs of crossing strands (12, 13, 23).

2. For 2-braid TQC one obtains 6 bits at each crossing of 3-D grid. The first bit tells whether reconnection occurs and second tells which of the resulting crossing strands goes over the other. One can imagine even a concrete realization. DNA strand which is a coil with radius of 10 nm could be accompanied by a flux tube and there would be for each codon to flux tubes crossing this flux tubes so that 6 bits would be needed to characterized the 2-braid

locally. DNA as TQC model suggests that second flux tube connects DNA codons to a helical flux tube at lipid layer of nuclear or cell membrane. Second strand could connect it to similar tube at cell membrane.

3. Just for fun one can imagine also a second, even more science fictive realization. If one further piles 3D TQC: s in 4-D one obtains 4-D one making sense in zero energy ontology because failure of strict non-determinism is basic element of TGD. Single crossing would in 4-D would involve crossings of four lines in orthogonal dimensions. TGD predicts also space-time regions with Euclidian signature in all scales (lines of generalised Feynman diagrams). I have proposed that any system corresponds to an Euclidian space-time sheet having its size and shape and behaving like quantum system. In these regions the fourth piling might really make sense!

   This would make 6 crossing pairs corresponding to 6 planes in which particular TQC takes place - for which one must tell whether to swap or not (12, 13, 14, 23, 24, 34). This makes 6 bits. DNA codons correspond to 6 bits! Could codons define crossing points of magnetic flux tubes arriving from 4 coordinate directions- perhaps at Euclidian space-time sheets? Could the planes correspond to 3 components of magnetic field and 3 components electric field. Magnetic flux tubes and electric flux tubes in 3 directions? In Euclidian regions magnetic and electric do not differ intrinsically. It is however difficult to concretize this proposal.

   In the following I try to understand the observations reported by Anirban Bandyopadhyay (`http://tinyurl.com/ze366ny`) in TGD framework.

The observations of the group of Anirban Bandyopadhyay from TGD point of view

The observations of Anirban Bandyopadhyay are briefly summarized by Massimo Pregnolato. At this stage one can of course several models for the findings and in the following one option is selected.

1. The most plausible model is based on the notion of coordinate grid formed by longitudinal and transversal magnetic flux tubes whose crossing points are the points at which swap occurs or does not occur depending on the state of tubulin dimer. The grids associated with A and B tubules are obtained by a 2π twist for the upper end of the tubulin.

2. There is a large number of options for grids and they are identified on basis of the experimental findings. Transversal coordinate lines would correspond to the 7-periodic parallel lines with either gap 2 or 3 (gap 4 lines decompose to gap 4 and gap 2 lines) and longitudinal coordinate lines to one of 4 line groups involving four gaps so that 8 coordinate grids are obtained and related by a 2π twist for A and B tubules respectively. Gaps could characterize measurement resolution.

3. For A-type microtubule one can consider also Fibonacci grids constructed from helical curves and their mirror images with periodicities 3, 5, 8, 13 and arbitrary gaps but it is difficult to interpret the resonance frequencies and understand their number for this option.

   1. Fröhlich B-E condensation or something else?

   Excitation at the resonance frequencies cause microtubules to assemble extremely rapidly. This is proposed to be due to Fröhlich condensation. The resonance frequency of AC stimulation leading to a rapid generation of microtubules in the length scale range $[.2 - 22.5]$ μm is around 8 MHz. There is correlation between resonance frequencies and lengths of microtubules and qubit sets that are possible.
   Comment: The identification as formation of Fröhlich B-E condensate can be criticized. The frequency at which this would take place was predicted by Fröhlich to be around GHz rather than in MHz range.
   In TGD framework AC stimulation could generate flux tube grid or activate existing magnetic flux tube grid forming a braid like structure serving as a template for the formation of microtubule around it. If the formation of grid corresponds to quantum criticality, the resonance frequencies could also generate phase transitions between A and B type states of the microtubuli.

AC signal could also generate contacts to these flux tubes making possible supra currents. The formation of microtubules is known to proceed by the formation of vertical nucleotide polymers which are then glued together horizontally: flux tube could serve as a template for the formation of the nucleotide polymer. The magnetic fields at flux tubes can be accompanied by helical electric fields (in this case both magnetic and electric fields are helical) and these fields could be responsible for the polarization of microtubule and induce the growth of microtubules in such a way that the polarized alpha-beta tubulin always attaches in the same manner to the growing polymer. Fröhlich condensation would be a consequence of generation of flux tube coordinate grids defining microtubule skeleton- growth of the magnetic body would precede that of biological body.

The length of the tubule increases with resonance frequency which suggests that single tubulin dimer is added to the polymer during each cycle. MHz range and formation time around few seconds. This would mean something like 10^6 giving MT with length of order 10^{-4} meters. The order of magnitude is correct.

2. 8 resonance frequencies in AC stimulation and 8 distinct interference patterns

Microtubules are reported to have 8 resonance peaks for AC stimulation (kilohertz to 10 megahertz), which appear to correlate with various helical conductance pathways around the geometric microtubule lattice. The explanation is proposed in terms of current pathways which are identified topological qubits.

Comment: To me this terminology looks strange and confusing. Why not to speak about braid strands or specify what topological qubit means if one is speaking about TQC? I am unable to understand why groups of parallel pathways are considered as topological qubits (TQs). The idea about parallel translates might however make sense.

As already explained, the notion of coordinate grid in the sense discussed is consistent with the findings. The resonance frequencies could correspond to phase transitions changing A-type coordinate grids to B-type or vice versa. Coordinate grid would define the basic architecture of TQC.

The second claim is that there are altogether eight distinct quantum interference patterns from a single microtubule, each correlating with one of the 8 resonance frequencies and pathways. According to the interpretation discussed in the talk 4 sets of four pathways representing quantum TQ each can exist simultaneously for type A microtubules claimed to be ideal for quantum computation. Lattices of type B exhibit 4 different pathways and are claimed to be ideal for communications. The lattices A and B are complementary in the sense that together they allow all possible pathways (this is not quite true: $n_{gap} = 12$ is lacking). The set of possible pathways depends on the length of MT.

Comment: Also this would conform with the TGD inspired model in which one has 8 coordinate grids for tubules of B and their deformations by twist to A type tubules. The 8 interference patterns would correspond to different coordinate grids. What coordinate grids are physically allowed coordinate grids are depends the length of the microtubule.

3. Observations about conductivity

There are also several observations about conductivity suggesting quantum coherence.

1. In assembled microtubules AC excitation at the resonant frequencies causes electronic conductance to become lossless, or "ballistic", essentially quantum conductance, presumably along these helical quantum channels. Resonance in the range of kilohertz demonstrates microtubule de-coherence times of at least 0.1 millisecond. Does this mean that AC signals at resonance frequencies are able to create these channels or groups of them?

   Or does this mean, that the resonance signal transforms the microtubule to A (or B) type lattice which is highly conducting or even super-conducting (via magnetic flux tubes). The claim that A type lattice does not exist in vivo reduces to the statement that it does not exist stably in vivo. The AC signal at resonance frequency induces the twist taking lattice B into lattice A in which TQC is possible.

2. There are three frequency scales corresponding to kHz Hz, MHz and GHz ranges. The natural identification for these rather low frequency scales is in terms of cyclotron frequencies of dark electrons and possibly also various ions at magnetic flux tubes. The simplest identification

would be in terms of three ranges for the strengths of magnetic field. I have proposed that.2 Gauss magnetic field define endogenous magnetic field explaining the effects of ELF em radiation on brain in terms of cyclotron transitions of biologically important ions, in particular Calcium ions for which cyclotron frequency would be 15 Hz (later an alternative explanation making essentially the same predictions has emerged). For electron the cyclotron frequency would.5 MHz so that for 16 times strong field would correspond to cyclotron frequency of 8 MHz appearing as resonance frequency. GHz frequency would require a magnetic field of.04 Tesla.

3. It is stated that the system cannot be classified as insulator, semiconductor, or conductor. The reason would be that the two bands involved do not overlap as in conductors, are not completely separate with large gap as in insulators, nor separate with a small gap. Instead the bands touch each other in pointwise manner.

   Comment: Stimulus with the resonance frequency could regenerate the flux tubes or bridges to the flux tubes allowing the transfer of electrons to them. The ballistic resistance temperature independent resistance would be due to a very long free path or due to super-conductivity at the magnetic flux tubes - the latter is the TGD inspired hypothesis. This kind of behavior could result if the electrons can leak to the flux tube only if they have same momentum as the Cooper Bose-Einstein condensate at the flux tube. Resonance condition would mean that the magnitude of the wave vector of electron is quantized in magnitude: this would also support the proposed interpretation.

4. It is claimed that conductance does not depend on microtubule length, is temperature independent, and has discrete values. Also ohmic dissipation is claimed to be negligible.

   Comment: The interpretation could be in terms of superconducting current pathways defined by magnetic flux tubes looks natural as already found.

The observation that water is necessary for MT conductivity [J65] suggests that the presence of water is essential for large h_{eff}. One of the many possibilities is that the flux tubes (which are closed) return through the interior of MT containing the ordered water. Also dark variants of genes realized as dark proton sequences dark nuclei could be involved.

4. Ferroelectric hysteresis

What is interpreted as ferroelectric hysteresis is claimed to demonstrate memory capacity in microtubules [J66]. Current viz. voltage over the microtubule exhibits square hysteresis. Suddenly all-in one jump changing the direction of current at critical voltage. This is analog of ferromagnetic or ferroelectric behavior but in completely quantal manner.

One can ask whether the quantum superpositions of two current directions might represent qubit. If so, the information processing capacity of microtubule would be rather modest unless one consideres seriously 2-braid TQC. (recall however that in neuroscience single neuron is assumed to represent bit).

It is not at all obvious that ferroelectric hysteresis is in question and TGD suggests different interpretation for the hysteresis curve. The current as function of voltage could reflect quantum coherent current in Bose-Einstein condensate of electronic Cooper pairs with all Cooper pairs having the same momentum. Macroscopic quantum coherence would make the state stable against perturbations defined by the external voltage and only when the voltage exceeds critical magnitude the state would change its momentum to opposite values instantaneously. If the interpretation as cyclotron BE-condensate is correct one would have Cooper pairs with spin 1 in same state and effectively only single particle representing memory.

The assumption of Bose-Einstein condensate might be unnecessary strong: negentropic entanglement might be enough. Dark electrons are negentropically entangled and the entanglement stores potentially conscious information. The degeneracy of the ground state essential for achieving stable enough entanglement also in standard approach to TQC. The NE would not be in spin degrees of freedom but in those labeling sheets of the covering of M^4 and CP_2 defined by the space-time sheet of electron. Anti-symmetry in these exotic degrees of freedom would make electrons bosons if seen from the perspective of standard physics and allow them to effectively B-E condense to the same state with respect to standard quantum numbers. Note that this proposal resembles

somewhat the proposal of Hameroff and Penrose for topological qubits in terms of parallel current pathways with same gap. In this case the NE could perhaps stabilize the state in the sense that NMP [K70] would not allow the quantum jump leading to opposite direction of electron current to take place.

5. Dynamical instability of MTs

MTs are dynamic instable and the length of MT changes in jumps. The conjecture is that some kind of language is involved. On basis of few second time scales one can wonder whether the correspondence with language production could be rather direct. Could regions of type A contain the information communicated in speech, say the information needed to form words or sentences? If microtubules of type B are indeed responsible for communications, one can ask whether $A \rightarrow B$ phase transitions generate the signal in turn inducing the nerve pulse patterns correlating with internal speech. The connection with language could be realized also at gene level [K52].

I have proposed that microtubule acts as quantum antenna emitting radiation with frequencies $f_n = nc/L$, where L is the length of MT. The variation of the length of microtubule would predict frequency modulation of the radiation coding for potentially conscious information. The model for nerve pulse and EEG makes similar prediction [K92, K44]. Josephson frequency for cell membrane as Josephson junction is proportional to membrane voltage and the variations of membrane voltages due to oscillations and nerve pulse activity are coded to EEG via frequency modulation. Even ordinary speech involves frequency modulation as is clear by listening recorded speech with abnormally slow speed. If microtubules talk, the most natural language would be based on frequency modulation.

The system seems to be critical, maybe it is quantum critical in TGD sense. At quantum criticality the dynamics involves a large number of length scales. In TGD framework quantum criticality would mean that the hierarchy of Planck constants is involved such that given length scales is proportional to the effective value of Planck constant. Maybe different lengths for flux tubes correspond to values of effective Planck constant $h_{eff} = nh$.

The important conclusion suggested by the experiments is that microtubules - in particular, brain microtubules - are macroscopic quantum systems. Already this would be enormously important conclusion. To my personal opinion, the interpretation in the talk is not convincing at the level of details and TGD inspired modification of the proposal in terms of flux tube coordinate grids making possible TQC architectures with tubulin dimers defining bits defining in turn TQC program looks more plausible to me. A natural generalization of of 1-braid TQC to 2-braid TQC is also highly suggestive in TGD framework and could be seen as evolutionary step assignable to the emergence of microtubules. The interpretation based in Fibonacci conduction paths fails to predict correctly the number of resonances. An attractive interpretation for the resonance frequencies is in terms of phase transitions between A and B type lattices. If A type lattices can be generated only in h_{eff} increasing phase transitions induced by AC stimulus at resonance frequencies, one could understand their experimental absence and why super-conductivity like state is generated.

2.13.7   Morphogenesis, Morphostasis, And Learning In TGD Framework

Michael Levin and his collaborators have been working with fascinating topics including fundamentals of long term memory and morphogenesis and morphostasis [I110, I111, I141]. I am grateful for Lian Sidorov for bringing these articles to my attention.

There are two articles about morphogenesis and morphostasis. The first article [I110] (`http://tinyurl.com/y9le7wme`) seems to be directed to general audience and has the title "The wisdom of the body: future techniques and approaches to morphogenetic fields in regenerative medicine, developmental biology and cancer". Second article [I111] titled "Morphogenetic fields in embryogenesis, regeneration, and cancer: Non-local control of complex patterning" (`http://tinyurl.com/ydfq28cb`) is more technical. The basic notion is morphogenetic field, an old notion, which has not captured the attention of main stream biologists who have worked mainly with the attempt to reduce biology to genetic code. Sheldrake's work [L9] with the notion has drawn special attention but there are many other workers in the field.

The third article [I141] by Levin and Shomrat has title "An Automated Training Paradigm Reveals Long-term Memory in Planaria and Its Persistence Through Head Regeneration" (`http://tinyurl.com/ycsfs6zc`) challenging the belief that brain is the only seat of memories.

According to Levin, the basic challenge of morphogenetics and morphostasis is to understand how the shape of the organism is generated and how it is preserved [I111]. The standard local approach based on belief on genetic determinism does not allow answer these questions satisfactorily. There is paradigm based on self-organization in which the local dynamics of cells leads to large scale structures as self-organization patterns. The game of life is an elegant example about how simple cellular automaton can lead to surprisingly complex behaviors: actually the game of life is universal Turing computer. The problem of this approach is that it is very difficult to deduce the local rules governing the behavior of basic units (whatever they are) in practice- especially so if they are also dynamical.

Second approach could be seen as computational with basic idea being that the process is guided by a template of the target state. Morphogenetic fields would define this template. The assumption about final goal can be argued to be too strong: much weaker principle defining a local direction of dynamics and leading automatically to the final state as something analogous to free energy minimum in thermodynamics might be enough. Unfortunately, second law is the only principle that standard physics can offer.

These problems are very relevant also for medicine [I110] since morphogenesis, morphostasis, and cancer all involve actively replicating cells: the difference is that in cancer the control and long scale coordination of the process fails and it becomes purely local process. Levin refers to cancer as geometric disease and it seems that this correction contains seed of truth.

These topics are also interesting from the point of view of TGD inspired quantum biology and consciousness. There are several new notions to be tested.

1. The new view about time and quantum implied by zero energy ontology (ZEO). In TGD framework the notion of preferred extremals as 4-D space-time sheet analogous to Bohr orbit, for which strict determinism of dynamics fails, replaces 3-space as basic unit. One can understand self-organizaton process in 4-D sense rather than 3-D sense: geometric time evolution would be replaced by subjective time evolution by quantum jumps. This could resolve the basic difficulty of the ordinary self-organization paradigm. Geometro-temporal pattern approaches to asymptotic quatum jump by quantum jump one rather than 3-D pattern.

2. The new view about information relying on the notion of negentropic entanglement and Negentropy Maximization Principle (NMP). NMP could be the principle guaranteeing local positive goal making healing and evolution basic processes of Nature. In particular, the development of shape and shape preservation of organisms could involve NMP in essential manner. Also the approach of WCW spinor field to the maximum of vacuum functional (or equivalently that of Kähler function) gives a goal for the dynamics after the perturbation of the organism causing "trauma". If Kähler function is classical space-time correlate for entanglement negentropy, these two views are equivalent.

3. The notion of magnetic body (MB) carrying dark matter as phases with large value h_{eff} of Planck constant making living matter a macroscopic quantum system and providing a tool kit of quantum mechanisms (phase transitions changing the value of h_{eff} and thus the length of flux tube, reconnections changing the topology of magnetic Indra's net, and 1-braiding of flux tubes 3-space and 2-braiding of their orbits in 4-D space-time). Magnetic body defining a kind of coordinate grid is a good candidate for the TGD counterpart of morphogenetic field serving as a template for the developing organism. It would also give rise to topological quantum computation (TQC) type activities.

   The coordinate grid formed by flux tubes defines 3-D topological quantum computer program and the natural assumption is that learned behaviors are coded by the magnetic body as TQC programs. If replication of magnetic body accompanies the replication of DNA, cell, and even planaria (say), the learned behaviors are also replicated.

4. There are additional mechanisms: super-conductivity made possible by large values of h_{eff}, Josephson radiation from Josephson junctions transforming voltages to frequencies inducing resonant transitions, and radiation consisting of dark photons and inducing cyclotron transitions serving as a basic control and coordination tools. The radiation could be generated as analog of cyclotron radiation by quantum phase transitions at magnetic flux tubes, by

Josephson junctions, and by microtubules serving as quantum antennas. Frequency modulation is an excellent candidate for the representation of information: kind of whale song would be in question.

All these new notions seem to be highly relevant for the understanding the findings challenging the standard intuition discussed in the articles. It would seem that both computational aspects (TQC), self-organization but in 4-D sense, the idea about template identified in terms of flux quanta of topologically quantized classical em fields, and the local direction of quantum dynamics defined by NMP are involved rather than single principle.

The notion of time in TGD framework

The TGD based notion of time is very relevant in attempts to understand the findings about the memory of planaria and metamorphosis and metastasis challenging the standard thinking.

1. The general picture based on zero energy ontology

1. In TGD framework one must make a distinction between subjective time and geometric time: usually these times are identified. Subjective time has state function reduction/quantum jump as chronon. Geometric time is the time of physicists and corresponds to one coordinate for space-time surface or embedding space. General Coordinate Invariance implies that it is not unique but that there are very natural choices of it dictated by symmetries.

2. In zero energy ontology (ZEO) physical state is replaced with a pair of positive and negative energy states at opposite boundaries of $CD \times CP_2$, where CD is causal diamond identified as the intersection of future and past directed light-cones. I will talk about CD in the sequel without bothering to write "$\times CP_2$". In ordinary positive energy ontology zero energy states correspond to initial and final states of physical events. The space-time surfaces having their ends at the boundaries of $CD \times CP_2$ are space-time correlate for the physical time evolution between the initial and final states. CD: s form a fractal hierarchy since the distance between the tips of CD is assumed to be integer multiple of CP_2 time. Also Lorentz transforms and translates of CD are allowed so that it makes sense to speak about moduli space of CD: s and also have "wave functions" in this moduli space. This is very relevant for understanding what the flow of time corresponds physically.

   One can say, that due to the failure of strict determinism the 4-D space-time surface connecting boundaries of CD becomes the basic dynamical unit as far as subjective time development is considered. The superposition of space-time sheets is recreated again and again in quantum jump so that "quantum average" space-time - also its past - changes.

   One can speak about 4-D body, brain, even society and there is continual 4-D interactions. For instance, the recall of long term memories could be communications with the geometric past using time reversed signals reflecting back from the brain of the geometric past: essentially seeing in time direction would be in question. One can even consider healing process in which the healthy state result also in the geometric past!

   A new view about long term memories emerges: the brain of geometric past can serve as the seat of memories. This applies to genuine conscious memories such as episodal memories but not to learned behaviors.

3. Zero energy ontology (ZEO) implies a new view about state function reduction and about how the experience about flow of time and its arrow emerge. The state function reductions can occur at either boundary of CD but also repeatedly at same boundary. The wave function in the moduli space of CD: s with fixed "lower boundary" changes although in each repetition of state function reduction although the positive energy state at "lower" boundary remains unchanged. In ordinary quantum measurement theory nothing would change. This change gives rise to the experience about flow of time. The change is that the average temporal distance between the fixed tip of "lower" boundary and the tip of the "upper boundary" increases: essentially dispersion leading to the decay of wave packet is in question. It is analogous to diffusion in which distance of the diffusing particle from the initial position

gradually increases. One can quantify this by introducing the average increase of average geometric time in single state function reduction highly relevant for understanding time experience.

4. Couplings between several widely different length and time scales - say molecular length scale and the scale of biological body - seems to be needed in order to understand morphogenesis - at least as something implied by cell level events. TGD assigns to each particle its CD. The scale of the smallest CD assignable with the particle characterized by given p-adic prime p corresponds to its secondary p-adic length/time scale. For electron this time scale is .1 seconds defining a fundamental biorhythm: as a length scale it corresponds to the circumference of Earth.

5. One of the basic predictions of TGD is the failure of strict determinism of the time evolution for space-time surfaces. The interpretation is as a space-time correlate of quantum non-determinism. The reason is the huge vacuum degeneracy of Kähler action. Any space-time surface with vanishing induced Kähler form which is essentially Maxwell field, is vacuum extremals. Mathematically this huge degeneracy is like gauge degeneracy but implies 4-D (very essential distinction from standard view) spin glass degeneracy: there is huge number of different preferred extremals obtained as deformations of the vacuum extremals. This means non-determinism.

So called vacuum functional tells the probability of one particular preferred extremal and one can imagine plotting it as a functional of the extremal. The graph would be a fractal analogous to free energy landscape of spin glass: there are minima inside minima inside.... - now only the minima are replaced with maxima.

2. What healing in 4-D sense could mean?
The TGD view about time allows to imagine what 4-D healing could mean.

1. Suppose that one performs a deformation of the space-time sheet representing healthy organism. The system suffers "traumatic injury" in 4-D sense but only inside the CD in question. Classical non-determinism makes also possible the that the localization of 4-D deformation to a finite region of space-time rather than extending to infinite future. State functions repeatedly replace the zero energy state with a new one and it can gradually end up back to the maximum of Kähler function unless the deformation was not too large or unless it stucks to a different local maximum. If it ends up with a original maximum, one can say that 4-D healing took place. Also the biological body of geometric past is healthy! In geometric sense the system was never sick! This mechanism requires no knowledge about healthy state and no algorithm for getting back into healthy state. Nature takes care of healing.

2. The sticking to a local maximum of vacuum functional can prevent getting to the ideal healthy state. This can be avoided by the same mechanism as in annealing, which serves as a metaphor in numerics for a process in which one finds deep minimum of function by "kicking" the system now and then to get out of local minimum. Now the "kicking" would be stimulus deforming the system but not too much.

3. One expects that also Negentropy Maximization Principle (NMP) is closely involved with healing since healing should involve regain of the lost information. NMP states that the total negentropy increases in state function reductions and is apparently the opposite of second law: the negentropies in question are however not the same thing and NMP implies second law for ordinary entanglement. The implication is that the potentially conscious information associated with the negentropic entanglement (with identical entanglement probabilities for entangled states) tends to increase and negentropic entanglement (see **Fig. http://tgdtheory.fi/appfigures/cat.jpg** or **Fig. ??** in the appendix of this book) can be only transferred to another system or transformed to a new form, but cannot disappear. Negentropically entangled systems would define kind of Akashic records storing potentially conscious information transformed to conscious information in interaction of free quantum measurement. The approach towards maximum of negentropic and maximum of vacuum functional should closely to each other. Quite concretely, NMP could help to understand why the pieces of planaria split into two parts develop head and tail.

4. Clearly, NMP and the approach to the maximum of Kähler function both define candidates for the principles giving rise to same outcome as morphogenetic field is hoped to give. A possible interpretation is that the approach to the maximum of Kähler function is the space-time correlate for NMP: Kähler function defined as Kähler action for preferred extremal could be regarded as classical negentropy.

3. The flow and arrow of time in ZEO

The TGD based vision about how the arrow of geometric time has developed slowly and I do not dare claim it be fully developed and final [K13].

1. What seems clear now is the decisive role of ZEO and hierarchy of CDs, and the fact that the quantum arrow of geometric time is coded into the structure of zero energy states to a high extent. The still questionable but attractively simple hypothesis is that U matrix relates two zero energy state basis with opposite quantum arrows of geometric time: is this assumption really consistent with what we know about the arrow of time? The second basis is always state function reduced.

   If this is the case, the question is how the relatively well-defined quantum arrow of geometric time implies the experienced arrow of geometric time. Should one assume the arrow of geometric time separately as a basic property of the state function reduction cascade or more economically- does it follow from the arrow of time for zero energy states?

2. The state function reductions occurs at either of the two boundaries of CD. If the reduction occurs at given boundary is immediately followed by a reduction at the opposite boundary, the arrow of time alternates: this does not conform with intuitive expectations: for instance, this would imply that there are two selves assignable to the opposite boundaries!

   It took time to realize that zero energy states must be de-localized in the moduli space CDs (the size of CD plus discrete subgroup of Lorentz group defining boosts of CD leaving second tip invariant). One has quantum superposition of CDs with difference scales but with fixed upper or lower boundary belonging to the same light-cone boundary after state function reduction. In standard quantum measurement theory the repetition of state function reduction does not change the state but now it would give rise to the experienced flow of time. Zeno effect indeed requires that state function reductions can occur repeatedly at the same boundary. In these reductions the wave function in moduli degrees of freedom of CD changes. This implies "dispersion" in the moduli space of CDs experienced as flow of time with definite arrow.

3. This approach codes also the arrow of time at the space-time level: the average space-time sheet in quantum superposition increases in size as the average position of the "upper boundary" of CDs drifts towards future state function reduction by state function reduction.

4. In principle the arrow of time can temporarily change but it would seem that this can occur in very special circumstances and probably takes place in living matter. Phase conjugate laser beam is a non-biological example in this respect. Memory recall [K96] would involve the change of arrow of geometric time for a subsystem corresponding to the signal propagating to the geometric past and reflecting back.

This vision involves minimal number of assumptions and is the most convincing one found hitherto and the challenge is to invent objections in order to develop it in more detail.

The notions of magnetic body and dark matter hierarchy

The notion of magnetic body is central in TGD. The TGD inspired model trying to explain the findings about microtubules by Indian research group led by Anirban Bandyopadhyay lead to rather interesting speculations about the role of magnetic flux tubes and a more precise speculative view about how living system could act as topological quantum computer [K88] [L22].

Remark: Magnetic body is somewhat misleading term since a simple deformation implies that magnetic flux quanta carry helical magnetic and electric fields along the flux tube axis.

1. Could magnetic body define coordinate grids making possible topological quantum computation?

If the claims of Indian research group led by Anirban Bandyopadhyay are true, one can say that microtubules are macroscopically quantum coherent systems at physiological temperatures. In his Youtube talk Anirban Bandyopadhyay (`http://tinyurl.com/ze366ny`) [J19] discussed an identification of conduction pathways different from that of Penrose and Hameroff. In [J75] Gosh, Sahu, and Bandyopadhyay argue for evidence for massive global synchronization in brain and claim that experimental findings support the Penrose-Hameroff theory. In the article "Atomic water channel controlling remarkable properties of a single brain microtubule: correlating single protein to its supramolecular assembly" [J65] it is reported that ordered water inside microtubule is necessary for the conduction inside microtubule.

According to the same article the tubulins inside microtubule has same energy levels in chemical energy range as isolated tubulins, which suggests that the mechanism binding tubulins to form MT is not chemical. In the article "Multi-level memory-switching properties of a single brain microtubule" [J66] it is reported that the hysteresis curve for current along MT as function of voltage is ideal square curve meaning that there is no dissipation involved with the change of the current direction. This would make MT as an ideal memory device. Whether Penrose/Hameroff have in mind the use of current direction as qubit remains unclear. In video talk Bandyopadhyay refers also to these results.

I have considered the general proposal discussed in video lecture in the article [K88] [L22]. The findings reported in the talk give support for the general TGD inspired view about TQC and allow rather detailed model in the case of microtubules. The idea is that flux tubes form a 2-D coordinate grid consisting of parallel flux tubes in two different directions: the guess that they could consist of helical Fibonacci flux tubes and their mirror images is not however convincing. Crossing points would be associated with tubulins and the conformational state of tubulin could define a bit coding whether the braid strands defining coordinate lines are braided or not (swap or not). In this manner any bit pattern at microtubule defines a particular TQC program. If also conformations are quantum superposed, one has "quantum-quantum computation". It however seems that conformation change is irreversible chemical reaction [J63] so that this option is not feasible.

The TGD inspired modification of the proposal in terms of flux tube coordinate grids making possible TQC architectures with tubulin dimers defining bits defining in turn TQC program looks more plausible to me. Coordinate grids can be fixed on the basis of the experimental findings and there are 8 of them. The interpretation is in terms of different resolutions. The grids for A and B type lattices are related by 2π twist for the second end of the basic 13-unit for microtubule. An attractive interpretation for the resonance frequencies is in terms of phase transitions between A and B type lattices. If A type lattices can be generated only in phase transitions induced by AC stimulus at resonance frequencies, one could understand their experimental absence, which is strong objection against the Penrose-Hameroff model.

This would fit very nicely with the general vision about frequencies as passwords inducing not only directed attention but activities in target - also TQCs! The increase of Planck constant could be associated with the phase transition to A-phase making possible high T_c dark super-conductivity for which evidence is observed! One can even deduce estimates for $h_{eff}/h = n$ if one requires that AC photons have energy above thermal threshold: $n = h_{eff}/h = f_{visible}/f_A C$ would be the estimate. For bio-photon energies one would obtain something like $n \simeq 10^8 - 10^9$, which pops up in different contexts in TGD framework.

This picture generalizes in the fractal universe of TGD. One can form layers of 2-D coordinate grids and connect them by vertical flux tubes to obtain 3-D grid defining TQC. The brain is known to have grid-like architecture and neurons could by quantum computation produce bit/qubit defining swap or not/superposition of swap and not-swap for a larger scale TQC. One would have fractal of TQCs.

A further idea is that the TQC based on 1-braids generalizes in a natural manner to 2-braid TQC in TGD framework (for 2-braids in 4-D space-time see [K56]. The knotting occurs for string world sheets defining the orbits of braid strands - say magnetic flux tubes idealized to strings. In the case of microtubules this option suggests itself: the emergence of MTs could have meant emergence of 2-braid TQC and the increase of abstraction level in the information processing.

In the node of 3-D coordinate grid either reconnection of two flux tubes can occur or not: this is coded by one bit. Second bit tells which tube goes over which tube in the plane defined by two tubes. There are three planes of this kind corresponding to xy, xz, and yz planes, and therefore 6 bits altogether. Could genetic codon containing 6 bits of information code for what happens in the node of the grid. Note that 2-braiding is possible only if string worlds sheets "live" in 4-D space-time: for super strings living in higher-D space-time this is not possible.

This kind of 3-D TQC could be responsible for the those aspects which are nearest to computation. One must be however very cautious with the word "computation". Space-like braiding seems to be very natural for storing memories [K5] in braiding patterns ad bit patterns would characterize the 2-braiding associated with the coordinate grid but from this it is long way to computation in the usual sense of the word.

2. Flux tube grids and coding of position information

In metamorphosis and metastasis the basic problem is how the information about position is coded. How cell does know its position in organism? This is necessary for the cell to express its genome in appropriate manner: for instance, gene expression of neuron is quite different from that of muscle cell? According to the article of Levin [I111] organisms seem to have developed kind of coordinate grids to realize this purpose. For instance, simple coordinate transformations seem to related the grids of nearby species to each other. Magnetic flux tubes could be basic building bricks of these grids and at the same time the realization of morphogenetic fields. The coordinate value could be coded by the value of local magnetic field strength varying along the flux tube. By flux conservation this would correspond to the thickness of the flux tube or equivalently to cyclotron frequency. Radiation at cyclotron frequencies would act resonantly only at points at which the resonance condition is satisfied.

Voltages associated with Josephson junctions define Josephson frequencies which could be essential for bio-control and coordination via the resonance mechanism allowing selective activation of biological programs. According to [I111], the values of transmembrane potentials in frog embryo correlate with the formation of the face of Zenopus laevis embryos. The lipid layers of cell membrane are proposed to form Josephson junction (at microscopic leve the ionic channels and pumps associated with them).

Fractality suggests that nearby cell membranes - say those associated with epithelial sheets - could also form Josephson functions as fractal considerations. Gap junctions could provide a microscopic realization of these Josephson junctions. If so, then the large h_{eff} Josephson photons with frequencies determined by transmembrane potential ($f = ZeV/h_{eff}$) could induce in resonant manner activities in precisely defined positions of the magnetic coordinate grid. The radiation at correct frequency would serve as kind of password allowing to initiate a biological program. For instance, in the case considered above they could initiate the generation of the face. The errors in development could be due to various birth defects could be due to external electric perturbations. Maybe, some day even the correction of these errors might be possible by using properly tuned electric voltages.

3. What happens to the magnetic body of planaria cut into two pieces?

When planaria is cut to two pieces, second pieces regenerates head and second regenerates tail. Also when one takes second cell away from 2-cell embryo, the remaining cell becomes a full organism rather than only half of it. If there is a template for the formation of organism, then also this template must split in two. As a matter of fact, I have proposed that the magnetic body of the cell decomposes to two in cell division and that this splitting actually guides the cell division.

The fractality of TGD Universe suggests similar splitting in all scales. The vertex of Feynman diagram representing the decay of photon to electron-positron pairs provides an ultra-simplified version of the replication. In TGD framework the lines of Feynman diagrams are replaced with 4-D orbits of 3-D surfaces (or by holography 3-D orbits of 2-D partonic surfaces) and this is true in all scales. Therefore the idea that magnetic body replicates would reduce one of the most mysterious processes of living matter to generalization of fundamental physics. Note that string models do not allow analogs for the vertices of Feynman diagrams, they are possible only in TGD framework.

The idea about magnetic body defining a coordinate grid serving as a counterpart of morphogenetic field or as template able to guide the development of the organism becomes central. It seems that even individual cell - perhaps even DNA - should contain microscopic representation of

some topological aspects of the adult organism. This conforms with the notion of holography and is consistent with the central role of genes. Magnetic body with large h_{eff} being very multi-sheeted structure analogous to covering space could provide this representation. With inspiration coming from Hox genes and from deep ignorance about genetics I proposed that the magnetic body of DNA and even DNA in some rough sense could be homologous to the biological body [K63].

Can one test this hypothesis? It is also possible to isolate the cells of planaria during the development of new head by closing gap junction connections between them for about 48 hours [I111]. The outcome is planaria with two heads. As if the isolation of two cells which should have belong to the head of planaria had induced splitting of the magnetic body assignable to the head to two so that the outcome was too separate heads. One can however split the two-headed planaria again and the headless part develops now two heads! If the two headed magnetic body replicates, the outcome follows as a prediction.

Is brain really the seat of memories?

Levin and Shomrat tell about experiments demonstrating that brain is not necessarily the seat of memories as usually assumed. Planaria have brains and they are able to learn and remember. When planaria is split, the pieces develop head and tail. In the experiments planaria are taught some skill and after that split into two pieces. According to [I141], there is evidence that the part of planaria with new head remembers the skill. From this one can conclude that brain is not the only possible seat of memories.

Before continuing, it should be emphasized that memories are now defined as learned behaviors - assumed to reduce basically to conditionings of neurons at the motor areas of brain so that they generate certain motor response to sensory input. In TGD framework memories are understood as genuine conscious memories about events of past and involve communication with the geometric past.

One can imagine several explanations for the findings about the memory preservation. The computationalist possibility is that memories are transferred at least temporarily to the body of planaria and then back to the new head. This does not look biologically feasible.

Three TGD inspired explanations - corresponding to the identification of the brain of the geometric past, biological body, or magnetic body as the seat of memories - are considered.

1. Memories - identified as conscious experiences analogous to episodal memories rather than learned skills - could reside in the old brain or biological body or even magnetic body of the planaria with new head in the geometric past and accessed by negative energy signals which are time reflected from it. This explanation is not natural when memories are identified as learned skills, which in the ideal case are un-conscious behaviors.

2. In TGD Universe entire body and brains could form a hologram like structure [K23] and the information about body is transferred to the new brain. This would be like hologram completion. TGD indeed suggests strongly that entire body is conscious. For instance, the sensory organs carry the primary sensory qualia, one could circumvent the problem caused by the fact that neural circuits seem the same in all sensory areas. Cortex - maybe entire brain - would build standardized cognitive mental images, give them names, and entangle them with sensory qualia at sensory organs.

   Phantom leg is the basic objection against this view but new view about time allows to circumvent it: the seat for the experience about pain in phantom leg is in geometric past when the leg still existed. Note that here memories are not learned skills but memories about genuine events in geometric past. The memory feats of idiot savants and people with left brain damage would be most naturally also due to sensory (visual or auditory) memories. Also ordinary people can have sensory memories when neurons in temporal lobes are stimulated electrically.

   Second TGD inspired explanation for phantom leg would be it is that phantom leg corresponds to the magnetic body part: it is however not clear whether the sensation of pain even other bodily sensations can be located at magnetic body.

3. The long term memories of planaria restricted to learned behaviors could be represented also at the magnetic rather than biological body. Quantum computationalist would agree with

this idea since learned skills would be very naturally TQC programs realized at the coordinate grid formed by the magnetic flux tubes. If magnetic body is replicated as planaria is cut to two pieces, also the TQC programs are replicated. DNA as TQC proposal [K5] assigns these programs to the braids defined by flux tubes assumed to connect DNA nucleotides or codons with the lipids of the lipid layers of the nuclear or cell membranes.

4. Could the state function reduction sequence implying 4-D self-organization driven by NMP lead to and asymptotic state in which also the skills learned in possession of old brain are possessed. As a matter fact, this aspect is certainly present since the replica of the magnetic body of planaria brain must give rise to original biological brain. TQC programs for the skills would be however present from the beginning.

5. In Zero Energy Ontology the space-time surface connecting 3-surfaces at the opposite light-like boundaries of causal diamond are the basic objects. The maxima of Kähler function correspond to very special pairs of 3-surfaces connected by space-time surfaces. One can say that 4-D dynamical patterns, "behaviors" are fundamental objects. In ordinary ontology they would 3-D patterns perhaps interpreted as asymptotic states resulting in self-organization.

The second option looks like the most plausible explanation since allows to understand the replication of not only organism but also the TQC programs defining behavior repertoire.

Chapter 3

Getting philosophical: some comments about the problems of physics, neuroscience, and biology

3.1 Introduction

This contribution was inspired by an FB discussion and is an attempt to summarize basic philosophical problems of biology and neuroscience and the TGD based solution of them. One cannot actually bypass basic philosophica problems of recent day theoretical physics so that the discussion begins with these. I wrote first version of this contribution 2018 and this version year later.

3.1.1 Importance of philosophical thinking

The FB discussion that motivated this work once again made manifest both the extreme importance and regrettable lack of philosophical thinking - not only biology but in natural sciences in general. I do not mean with philosophical thinking academic philosophy, which I have found mostly deadly boring. Rather, for me good philosophical thinking means posing critical questions - rather than personal insults.

What we really know and what we do not know? What do we believe and what part of this is just beliefs? Are there facts challenging these beliefs? What is consciousness: is it really a property of something as "-ness" suggests? What is free will? How it manifests itself? Is it an essential aspect of consciousness so that AI hype could be forgotten? Are free will and non-determinism really in conflict with physics as physicalist has decided to believe? Concerning consciousness, what guidelines come from modern, physics, biology, and neuroscience?

In physics critical thinking would have allowed to avoid the numerous fads and fashions that have plagued us during last 4 decades: GUTs that led to the wrong track, inflation theory, various ad hoc models of dark matter postulating some exotic strong AI, supersymmetry in its GUT form, superstring models, loop gravity,...

Critical thinking would have challenged various "interpretations" of quantum theory and we could have continued immediately the work of the fathers of quantum theory rather than waiting for almost a century. Critical thinking would have also inspired the question whether the non-determinism of state function reduction has something to do with free will and how one should generalize the ontology of physics (Copenhagen ontology gives is it up altogether) to build a logically consistent framework.

Unfortunately critical thinking tends to lengthen the time spent in academic assembly line so that it is strongly discouraged. Thinkers tend also to become isolated from their social groups since everyone of us wants desperately to belong to some group and this requires sharing of its beliefs. It is easier to believe what professor and text book tell and get the research position and funding.

People are also very lazy. AI scientist decides that consciousness is running computer program or a property of the network structure or something equally ad hoc: no need to learn huge

amount of physics, biology, neuroscience. Biologist decides that biology is nothing but Schrödinger equation and electromagnetism (or mere chemistry as in the older variant of the belief still prevailing). Neuroscientist desides that physicalism is correct and brain is the seat of the consciousness module. Brain as a computer paradigm makes the situation even easier. Physicist decides to believe in physicalism stating in its modern version that all physics reduces to Planck length scale: one can safely forget all other branches of sciences as a kind of taxonomy and specialize to apply one particular algorith to build CV.

3.1.2   Basic dogmatics

The key dogmas common to all branches of natural science are physicalism and reductionism. Physicalism states that matter is all that matters and consciousness is mere epiphenomenon and that world is deterministic - in the quantum version of the dogma it obeys statistical determinism. Reductionist sees natural sciences are a victorious march towards shorter and shorter space and time scales. Science is an imperium that grows conquest by conquest.

We are told that super string theorists have taken the last step to Planck scale by building the only possible theory of everything. This step is really gigantic: from electroweak length scale there are 16 orders of magnitude to Planck length scale. Before this every order of magnitude has contained a lot of su4prises but now the situation would be different as already GUT theorists revealed to us.

The surprise was however that the theory in Planck length scale does not allow to predict anything in long length scales: situation is like trying to predict the behavior of initial value sensitive system. The question of philosopher would be obvious: could something have gone wrong? This question has been made by some theoreticians. The decision of elite however seems to be that physics has reached its end. Nothing can be predicted and we should be happy about this marvellous feature of the only possible theory.

This series of conquests is marked by transitions. From biology to biochemistry, from biochemistry in vivo to organic chemistry in vitro, from chemistry to molecular physics, from molecular physics to atomic physics. Then follows a transition from atomic physics to nuclear physics: the assumption is that these two physics have practically nothing to do with each other. There are numerous experimental anomalies found during the last century challenging this belief. "Cold fusion" people were labelled next to criminals for their scandalous claims. Luckily the situation has now changed. But people talking about water memory belong still to the pariah of science.

After this jump we jump from nuclear physics to hadron physics to physics at quark-gluon level and then comes the really really big Planck jump. So simple.

There is however a little problem. Every successful conqueror must build a lot of bridges, without them the maintenance fails. Reductionistic conquerors were so hasty that they did not have time to to build the bridges between these different physics. We do not understand how nuclear physics emerges from hadron physics emerges from quark physics. We do not understand how biochemistry emerges from organic chemistry emerges from molecular physics emerges from atomic physics. But we can decide that this is only a technical difficulty: if we had enough computational power we could fill these gaps.

Actually, I know a couple of finnish fellows who tried to fill a gap. The first one has read from text book that the notion of chemical bond emerges from atomic physics. He wrote a lot of computer programs and did not find a slightest indication for this. Second fellow had learned that cell membrane emerges and started to study a model in which one has just molecules and molecular dynamics simplifying the situation. Not a slightest indication.

3.2   TGD inspired view about the basic problems of physics, neuroscience, and biology

A reaction to not so thoughtful comments of a young otherwise friendly fellow in FB inspired me to ask why the young people who have got through the basic courses are not only ignorant but sometimes also - well - arrogant. Why they are ignorant is easy to understand but arrogance remains a mystery for me. Personally I was also extremely ignorant as also the my fellow students but quite too shy to be arrogant: could I have been as arrogant as other if I had not been so

hopelessly shy? This fellow had not understood much of what I had written - something completely acceptable, understandable, and predictable since something completely new is in question and text book wisdom or what professor said is simply not enough.

So he concluded that I am writing only weird fairy tales and that it seems that I have never heard about mathematics, electrodynamics, or thermodynamics. According to him these fields allow to understand biology more or less completely: maybe he read this from a text book or professor told this to him. My FB friend also wanted to know whether I have read any book about biology during my lifetime.

I responded that I have not only heard the word "biology" but have even written about quantum consciousness and quantum biology [K4] (1000+ something pages). I forgot to mention that I have also written two published books about TGD [K120, K7] and there are 17 online books at my homepage (9 of them about quantum biology) (see `http://tinyurl.com/yddldhoe` and `http://tinyurl.com/ycokk2kh`) plus numerous articles both published articles- in particular in journals edited by Huping Hu - and at my homepage (see `http://tgdtheory.fi/tgdarticlesall.html`). I told that I have also recently published a long article in a book published by Springer about adelic physics [L50, L51] (see `http://tinyurl.com/ybzkfevz`): the goal of adelic physics is to describe the correlates of cognition and consciousness in terms of number theory and whose most important applications are to biology.

I informed that I have also heard the word "thermodynamics" and even developed what I call p-adic thermodynamics providing a first principle approach to particle massivation replacing Higgs mechanism [K76] (see `http://tinyurl.com/y9z83aob`). I forgot to mention that quantum TGD can be seen formally as a complex square root of thermodynamics replacing Boltzman weights with the complex square roots defining vacuum functionals and that the generalization of so called microcanonical leads to extremely predictive view about scattering amplitudes serving as the building bricks of zero energy states [L68] (see `hhttp://tinyurl.com/yakzlllk`).

This discussion was not pleasant but very useful in that it inspired me to write a summary of basic philosophical problems of biology and neuroscience and the TGD based solution of them. I hope that I have not forgotten anything from the list.

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In the following the attention is restricted mostly to the philosophical problems of biology and neuroscience. It however turns that these problems are actually also problems of physics.

3.2.3   Nothing but biochemistry and electromagnetism?

The basic dogmatics says that life is nothing but chemistry plus a little bit of electromagnetism needed to model cell membrane and neuronal membrane. There is also EEG but this is taken as noise due to neural circuits so that there is no need to waste time with it. Luckily, not all

experimentalists know or care about dogmatics and have found correlations of EEG with behavior and physiology and they are used as a diagnostic tool. Most of them however refuse to consider seriously the possibility that EEG might possibly communicate something from brain somewhere. Where would this somewhere could reside: outside brain?

No! Philosopher must be producing totally weird fairy tale now! Says the mainstreamer inside me with such a friendly ut delicate tone that it becomes clear that he regards the poor philosopher as a screwball.

But philosopher continues asking. Didn't Libet discover that our sensory data is fraction of second old? Could it take fraction of second of this data to propagate as EEG signals from brain to this something. As a matter fact, Libet discovered also that the conscious decision to raise finger is preceded by neural activity starting for a fraction of second earlier. One cannot understand this unless one decides that it supports the absence of free will.

Philosopher asks also whether our decision that experienced time and the time of physicist are one and the same thing is be wrong. They are indeed different in many respects as any first year physics student understands. Should we trust facts instead of textbook wisdom? And what about Libet's second finding: could we give up our firm decision that signals propagate in only single direction of geometric time?

There is also a second strange electromagnetic phenomenon in biology: bio-photons. Already discovered almost century ago, they are still taken as pseudoscience by many biologists. They appear in visible and UV range but it seems that they are not produced in molecular reactions (this would mean peaks in the distribution). What is their origin?

3.2.4 Why vivo-vitro difference?

Even the basic dogmatist must admit that one must speak about organic chemistry in vivo and in vitro. In vitro one can build models for reactions, deduce estimates for the excitation energies of molecules, construct thermodynamical models for reactions in terms of thermodynamics involving parameters like activation energies and chemical potentials, one can develop complex networks of reaction pathways.

The typical assumption of these models is that everything is homogenous and isotropic: one has spatially constant concentrations of various reactions obeying differential equations determined by the kinetics. One can however construct more complex structure by allowing diffusion making possible spatial gradients.

The problem is that this dynamics has very little to do with what happens in living cell. The in vitro estimates for the rates of reactions are many many orders of magnitudes too low as compared to those in living matter. We do not understand anything about bio-catalysis. We know that enzymes and ribozymes somehow make the miracle but that's all. We do not have slightest clue about how reactants manage to find each other in the molecular soup full of different molecules. We have no idea wherefrom the reactants get the energy to jump over potential wall making the reaction quite too slow.

Philosopher would say that here is an excellent opportunity for new physics to enter in biology. How can reactants find each other? Could they possibly be connected by something, which shortens as the reactants meet? Could the notion of tensor network involving quantum entanglement be essential element of biology and entire physics. Particles would not be lonely riders but could be connected by something at least temporarily. Could this something liberate energy quanta allowing to get over the potential wall making reaction so slow? Could these networks have dynamical topology and make living systems what they are.

Unfortunately, standard space-time picture does not allow this something. Also Planck constant is quite too small. Should we conclude that the philosopher is weirdly fairytaling again?

3.2.5 Where does the coherence come from?

A further mystery is how the biochemical reactions can occur coherently in length scales longer than atomic scale. Without this coherence I could not write this, play piano, or even raise my hand. If we were just sacks of water containing some chemicals we would be doing science and arts. We would be indeed just sacks of water containing some chemicals in chemical and thermodynamical equilibrium and microscopic sample from this water would characterize us completely.

Mysteriously the coherence of biodynamics in scales up to the size of the organism emerges somehow. The required coherence need not be quantum coherence - and probably it is not - but it could be induced by quantum coherence. Quantum coherence of what? There is also the problem due to quite too small value of Planck constant. We have learned about the effects supporting the vision about quantum biology. It is now however becoming clear that these effects would however require large value of Planck constant.

Here the philosopher remembers the findings of Blackman and other pioneers of bio-electromagnetism. They found that the irradiation of vertebrate brain by ELF radiation at EEG frequencies scale had effects on both behavior and physiology and these effects look quantal occurring at harmonics of endogenous magnetic field of .2 Gauss. $E = h \times f$ makes these effects extremely small and totally masked by thermal noise. What if the value of Planck constant were so large that the energies were above thermal energy?

Philosopher talks shyly about effective Planck constant $h_{eff} = n \times h_0$, where h_0 is the minimal value of h_{eff} and n is integer: h_0 would be actually the real value of Planck constant and h_{eff} would be associated with space-time surfaces, which are in number theoretic approach n-sheeted covering spaces [L45, L51, L50] and replaced at QFT limit with single slightly curved piece of M^4. n can be identified the dimension of extension of rationals assignable to the space-time surface and measures algebraic complexity. There are arguments that ordinary Planck constant is given by $h = 6h_0$ [L39, L59].

Now the mainstream physicist inside us is getting really angry: is this recklessly speculating philosopher really suggesting that our cherished quantum theory might not be the final word of science?

The dynamics of space-time surfaces

This dynamics predicts two kinds of space-time regions [L33] (see `http://tinyurl.com/yboog5sr`.

1. The regions of first kind are locally minimal surfaces. These minimal surfaces are as 4-D analogs of geodesic lines analogs of asymptotic states of particle physics for which interactions are not on. They also satisfy non-linear geometrization of massless field equations so that both particle and wave aspects are present. What is especially important is that static minimal surfaces have vanishing mean curvature and look like saddles locally. They cannot be closed surface if stationary.

2. Second type of regions are not minimal surfaces: there is a non-trivial coupling of the minimal surface term to 4-force density analogous to the divergence of Maxwellian energy momentum tensor. This is a generalization of the dynamics of a point-like charged particle in Maxwell field. These regions are identified as interaction regions: in particle physics these two regions correspond to external free particles and the interaction region. Magnetic flux tubes play fundamental role in TGD based quantum biology are deformations of string like objects, which represent simplest 4-D minimal surfaces.

   Essential is the coupling between induced Kähler form (mathematically like Maxwell field) and the geometry of the surface: the divergence of energy momentum current assignable to the analog of cosmological term (4-volume) equals to the divergence of that assignable to Kähler action: this expresses local conservation of four-momentum. One could also speak about coupling between Kähler field and gravitational field: Penrose's intuition about the role of gravitation in biology would be correct.

   When the coupling is absent, minimal surface property implies the separate vanishing of both divergences and separate conservation of corresponding energy-momenta. All the known extremals of Kähler action are minimal surfaces: this is due to their very simple algebraic properties making easy to discover them. Physically this correspond to quantum criticality: dynamics is universal and does not depend on coupling parameters.

3.2.6 Questions related to bio-chemistry

Biocatalysis

As already mentioned, bio-catalysis remains a total mystery in bio-chemical approach. Magnetic body carrying dark matter could provide the needed mechanisms. Actually these mechanism would be also basic mechanisms behind water memory and - dare I say it aloud? - homeopathy [K53].

According to TGD view about catalysis, reactants find each other by cyclotron resonance for dark cyclotron radiation assignable to massless extremals (MEs) possibly associated with U-shaped flux tubes. The U-shaped flux tubes of the molecules reconnect to a pair of flux tubes connecting the molecules. This occurs only if the flux tubes have same strength of magnetic field and therefore same thickness by flux quantization. The same value of h_{eff} guarantees resonance. The next step is the shortening of the flux tubes by a reduction of h_{eff} and liberating the energy kicking the reactants over the potential wall making the process extremely slow otherwise.

DNA replication, transcription to RNA, and translation of RNA to amino-acids are the fundamental processes in biology and TGD should provide a general model for them. Consider DNA replication as an example.

1. The standard model assumes that DNA opens and nucleotides build up the DNA codons in ordered manner. Nucleotides would be caught one-by-one from the environment by U-shaped flux tubes from DNA reconnecting with similar flux tubes from nucleotides. In the proposed model however dark codons are the fundamental units and expected to induce the process at the level of chemistry. Dark codons do not allow a decomposition to letters. Therefore ordinary codons rather than nucleotides should serve as basic units in energy resonance binding them to dark codons (triple resonance or ordinary resonance with respect to the sum of resonance energies). This looks like a problem for both replication and transcription. Translation in which RNA codons are paired with amino-acids suggests a solution of the problem.

2. Suppose that dark codons are the basic units also in the environment, and are connected by long flux tubes with rather large h_{eff} to ordinary nucleotides forming thus loose but actually strongly correlated triplets. Nucleotides would serve as basic units only apparently: the entities in question would be analogous to tRNA codons. In the replication and transcription the dark codons of opening DNA sequences would form flux tube contacts with dark codons in the environment coupled to ordinary loose codons by dark triple resonance.

   After that the Planck constant h_{eff} associated with the connecting flux tubes would be reduced, the flux tubes would shorten and the complementary dark codon would be drawn near the dark codon associated with DNA. Also the flux tubes connecting the dark codon to the nucleotides would shorten and the codon and complementary codon would form 3 base pairs. Shortening by a reduction of h_{eff} would provide the energy making the process fast enough. The loose codon property would allow to store the energy needed to make the reaction fast.

3. This model can explain also the claim of Montagnier *et al* [L7] about remote DNA replication [L7, L58]. Gariaev *et al* have reported the same process much earlier [I124] and together with Peter Gariaev we have developed a model for the process [K127].

   The situation is as follows. One has two vessels A and B: A contains genes and B only nucleotides. The vessels are connected by channels so narrow that the genes cannot leak through them. The system is irradiated at 7 Hz frequency, which is near the lowest Schumann frequency. The generation of the copies of genes in B is reported.

   The proposed model suggest that the flux tubes emanating from the dark DNA codons associated with the opening DNA extend to the other side - possibly through the channels so that there is a strong correlation between the directions of flux tubes and their endpoints are close to each other. If they have same value of h_{eff} they would have same length. They would reconnect with dark codons at the other side connected to nucleotide triplets by long flux tubes and the process would continue in the same manner as in the ordinary replication.

What selected the biomolecules?

Now philosopher is asking why only very few candidates for relevant biomolecules are actually selected. Who/what selected and how? This leads to very unpleasant questions circumvented by deciding that the emergence of life was nothing but a thermodynamical fluctuation. It has however become clear that complex organic molecules are present even in interstellar and intergalactic space. The miraculous thermodynamical fluctuation explaining evolution without real evolution would have been really huge.

Philosopher tends to conclude that we simply have no clue about what selection at the biomolecular level really is and continue that some new physics is involved so that it is time to think giving up the reductionistic narrative.

The selection problem appears also at the level of biochemical reaction pathways. One can imagine endless variety of "reaction vertices". If one assumes that only very few basic "reaction vertices" are allowed but the rest not, one can construct a limited number of reaction pathways. But this is an ad hoc assumption: this selection of allowed reaction pathways certainly occurs but we do not have a slightest idea about the physics behind it.

There is also an analogy with computer science. One can construct endless variety of linguistically correct computer programs: why only very few of them would be selected. And with neuroscience: from a huge array of behavioral patterns only some are selected.

Here one can of course try a loophole: Darwinian selection. But there is no selection in the Universe of physicalist. This would require free will and intentionality. The trick does not work.

But what about this network in which biomolecules are connected by this something already mentioned?, asks philosopher. Could this something connect only biomolecules if they are in the same relationship as sender and receiver of radio signal. Could these somethings connect stably only systems possessing common resonance frequencies? Could this criterion could select both the preferred biomolecules and the "reaction vertices" and thus also reaction pathways.

One can develop this idea further.

1. The resonance between systems with the same value of h_{eff} would be both frequency - and energy resonance. The resonance between systems with different values of h_{eff} requires change of h_{eff} of either system so that h_{eff} is same for the systems. Energy is conserved, which means that the frequency of the photon would change to satisfy $E = h_{eff,1}f_1 = h_{eff,2}f_2$. One would have only energy resonance.

   The resonance of dark matter states with bio-molecules would be energy resonance and make it possible for long scales to control short scales by inducing molecular transitions. The transformed photons could have interpretation as bio-photons [K20, K30].

2. One can however argue that mere resonance is not enough to select bio-molecules. Magnetic flux tubes containing dark particles can vary their thickness and by the conservation of the monopole flux also magnetic field and cyclotron frequency so that they can get in resonance with any bio-molecule. A stronger condition is required.

   The obvious idea is that also biomolecules can be in resonance and surviving bio-molecules are able to build networks. Selection would not be selection of mere individuals but that of networks able to co-operate. There would be a choir singing resonantly in unisono rather than only resonating pairs. The biomolecules involved would have common transition energies which would poses extremely strong conditions on survivors.

   It is easy to guess the reaction of the mainstreamer: fairy-taling again.

Genetic code

Genetic code definitely represents information. Is it really an outcome of thermodynamical fluctuation? Is there some deep mathematics associated with the genetic code?, asks the philosopher now. Be patient!

Genome contains also intronic portion: most of it consists of introns and the intronic portion is the larger the higher the evolutionary level is. The prevailing interpretation has been as "junk". Is it really junk?, wonders philosopher. Luckily, the attitude that trash bin represents the highest level of evolution has begun to slowly change to more rational one.

Could there be a beautiful mathematics behind genetic code? Could it be something similar to codes in computer science and have not only one representation - the chemical one - but numerous representations? If computer science would have developed before genetics - this question would have been completely natural and we would probably know a lot about these representations. Could this dark matter with large Planck constant at these mysterious somethings identified by our philosopher tentatively as magnetic flux tubes realize the really fundamental representation of the genetic code and also of of DNA, RNA, tRNA, and amino-acids (AAs) in information theoretic sense? And could also radiation provide realization of genetic code necessary for communications? This is what the philosopher claims [L34, L55, L54, L19, L69].

The most plausible vision at this moment is that since magnetic body is the boss, chemical code should be incomplete secondary representation of more fundamental genetic code realized at the level of magnetic body controlling bio-matter. The realizations based on 3-proton triplets and dark light 3-chords defining icosa-tetrahedral representation of the genetic code in terms of Hamiltonian cycles [L75] would be the deeper realizations. There would be several Hamiltonian cycles distinguishing assignable to the same chemical representation of the genetic code. The analogy with music suggests that the realization in terms of 3-chords defining bio-harmony gives rise to quantum correlates of emotions assignable to magnetic body as kind of higher level sensory perceptions. Genetic codon as 6-bit unit would correspond to the "bitty" aspects of intelligence and harmony would correspond to emotional intelligence as the holistic aspect of intelligence [L75, L19]. Emotions would be realized already at the level of magnetic body [L61, L57].

The recent findings that the RNA of a conditioned sea snail scattered over neurons of second sea snail in Petri dish generate neuronal correlates of conditioning (`https://cutt.ly/6SuLNqk`) supports the view that the magnetic body of the RNA of sea snail infects the emotion/mood related to the conditioning. The emotional state, mood, of DNA and RNA would affect gene expression. Epigenesis is a poorly understood in standard biology and could be based on emotional states lasting for several generations. This is natural in ZEO [L19, L82].

How different representations of the genetic code relate to each other?

1. The natural hypothesis is that given dark codon generates corresponding light 3-chord in communications and control. Alike likes alike rule of homeopathy suggests that triple resonance between identical codons is the basic mechanism of communications between various representations. Similar codons of DNA sequences would be in resonance if the mood defined by bio-harmony is same for them. For the same value of h_{eff} one would have both energy and frequency resonance for different values only energy resonance.

2. The condition that all possible - or at least some - moods coded by Hamiltonian cycles are realized, poses additional conditions on ordinary DNA codons since given codon should be able to respond to several 3-chords resonantly. An open question is whether ordinary codons responds via triple resonance or to the energy associated with the sum of the three frequencies in which case one can consider the possibility that the sum of frequencies does not depend of bio-harmony.

3. Since dark protons are entangled and do not allow a decomposition to letters, it is not possible to realize the correspondence with ordinary codons by assigning a frequency separately to each nucleotide: the chemical codon reacts as a holistic entity [L75]. This gives highly non-trivial conditions on transcription and DNA replication: DNA and RNA nucleotides must form loose codons connected to dark codon by long flux tubes and in transcription/replication these flux tubes shorten. This allows to understand [L7] also the remote replication of DNA reported by Montagnier *et al* [L7]. The loose codons formed by nucleotides and dark codons would be very similar to tRNA codons except that the flux tubes connecting dark codon to nucleotide would be long.

3.2.7   Metabolism

Metabolism is one of the key aspects of biology. We must eat and plants must busily photosynthesize in order to survive. But why metabolic energy feed is needed? Again a mystery.

Non-equilibrium thermodynamics

Non-equilibrium thermodynamics is one attempt to answer this question. Thermodynamical equilibrium is completely uninteresting, entropy is maximal and in the case of local dynamics the state of system is completely determined by a small sample of it. However, if one has energy feed, situation changes since equilibrium becomes flow equilibrium. The energy feed guarantees that there is macroscopic dynamics rather than mere thermal motion at microscopic level.

Also in this case one has essentially the same situation everywhere unless one introduces macroscopic parameters - also energy flow - depending on time and position to get something more interesting. Simple reaction kinematics determined by differential equations can be replaced with that determined by partial differential equations obtained by allowing diffusion. Also temperature, pressure and other thermodynamical parameters can be allowed to depend on position and time. Turing proposed a model for the coloring of Zebra as outcome of this kind of dynamics. The model for neuronal membrane and nerve pulse generation is also a rough model trying to reproduce basic facts about nerve pulse generation using thermodynamics for neuronal membrane regarded as a capacitor. This is of course a mere parameterization of the situation. TGD leads to a quantum model for the situation [K92]. Also the interpretation about the role of nerve pulse patterns at neuronal level changes dramatically [L44, L61].

In non-equilibrium thermodynamics one speaks of self-organization. One can generalize this notion to quantum self-organization and the crucial criticality associated to the transitions between different self-organization patterns generalizes to quantum criticality [K98]. Could these transitions correspond to spatio-temporal self organization patterns, behaviors, functions, programs. This in turn leads to deep connections with conformal symmetry (even its generalization in TGD), fractality, and universality of the dynamics. It is a pity that biologists do not seem to know much about these possibilities.

Now the philosopher starts to talk about ontology. Try to be patient. In standard physics the 3-D time= constant snapshot defines the state. This belief has led to weird proposals: in quantized general relativity one ends up with a proposal that there is no time at all.

ZEO based view about quantum self-organization

Could it be that 4-D deterministic time evolution between initial and final states could be more fundamental than the 3-D snapshot? Could superpositions of these 4-D evolutions define quantum states. If so, the state function reductions would occur between these superpositions and their non-determinism would be consistent with the determinism of field equations. Free will would not break laws of physics. It would be like starting new deterministic computer program. Our philosopher calls this ontology Zero Energy Ontology (ZEO) and claims that it leads to a theory of consciousness as a generalization of quantum measurement theory [L53] (see `http://tinyurl.com/ycxm2tpd`). Irritating.

ZEO based quantum measurement theory predicts that in ordinary state function predicts that the arrow of time changes in ordinary state function reductions but is preserved in "small" state function reductions identifiable as analogs of so called weak measurements. The recent strange findings of Minev *et al* [L77] provide direct evidence for the change of the arrow of time in state function reductions of atomic systems [L77].

ZEO predicts also the possibility of signals propagating backwards in time. This led to the vision that episodal memories involve communications with the brain of geometric past [K96], to the idea that motor actions and sensory perception are time reversals of each other [L70]: motor action would involve sending of negative energy control signals to the geometric past, and to the notion of remote metabolism based on quantum credit card mechanism. One can say that the system sends negative energy to a system able to receive it rather than receiving positive energy.

The energy of system as a function of h_{eff} increases when other parameters are kept constant. It costs energy build intelligence. h_{eff} for a given sub-system tends also to reduce spontaneously. Hence there must be continual energy feed to keep the level of conscious intelligence. A highly interesting possibility that this condition applies to all self-organizing systems. Self-organization generates long range coherence and requires energy feed. Could it be that dark matter makes itself visible by giving rise to long range correlations and coherence induced by dark matter at the magnetic body of the system [L87]?

Just as life also self-organization involves generation of coherence in long scales and requires energy feed. In the model for living system relying on dark matter as $h_{eff} = n \times h_0$ phases at magnetic body of the system coherence is induced by quantum coherence of the dark matter, and metabolic energy feed is required to increase h_{eff} tending to reduce spontaneously. Could self-organization be quite generally modelled in the same manner so that dark matter would make itself visible in everyday physics [L87]? Could the realizations of the genetic code in terms of dark nuclei and dark photon 3-chords be involved with the self-organization of water and be involved with morphogenesis?

Does metabolic energy feed generate conscious information?

The basic question about the role of metabolic energy remains, says the philosopher. What is its real role? Energy feed generates structures and structural complexity means information. It seems that metabolic energy feed involves also a feed of information or generation of information. And because living systems are in question, philosopher cannot avoid the question whether this information is actually conscious information. Is there any other kind of information than conscious information?!

To this question standard physics has no answer: it can only describe entropy mathematically and identification of information as lack of entropy is the easy answer suggested in lack of anything better. The question about a possible measure for conscious information analogous to Shannon entropy is one manner to end up with p-adic physics as a correlate of cognition and the necessary fusion of real and various p-adic physics leads to adelic physics [L50, L51]. Adelic physics in turn predicts - surprise- surprise - a hierarchy of phases of matter labelled by the value of Planck constant $h_{eff}/h_0 = n$ defining the dimension of the extension of rationals defining the adele. These phases residing at these somethings defining the networks - magnetic flux tubes - make possible macroscopic quantum coherence inducing the coherence of living matter.

Quite generally, the energies of states as function of h_{eff} increase. For instance, atomic binding energy scales decreases like h_{eff}^2 and cyclotron energies scale like h_{eff}. In order to generate phases with non-standard value of h_{eff} energy feed is needed. This energy is identifiable as metabolic energy.

In adelic physics [L51, L50] h_{eff} serves as a measure for the IQ of the living system in well-defined system. The higher its value, the better changes the system has for generating conscious information - and also for destroying it. This leads to a rather concrete view about the origin of good and evil. The ethics and moral are simple: good deed increases the conscious information of the universe. Conscious entity can choose whether to increase the conscious information of the universe or reduce it. Evil deeds indeed lead to a reduction of conscious information of the universe since the doer cannot confess others or even himself what he did. Also the members of community become secretive - complex encryption schemes develop. The self-knowledge of the universe knows is reduced. Luckily, evolution unavoidably occurs in statistical sense and resources of conscious information increase in long enough time scale.

Remote metabolism as a purely thermodynamical universal mechanism in ZEO

Quite recently (towards end of 2019) I found a more precice formulation for the intuitive notion of remote metabolism, which strongly suggests that energy is conserved in ZEO. There is a decomposition to system and the energy energy source: call them A and B. Intuitively, A receives energy from B by sending negative energy to B. What does this really mean?

1. A "big" (ordinary) state function reduction reversing arrow of time takes place: this would correspond to sending negative energy signal to past. The energy of A+B in the final time reversed state at new passive boundary of CD would be shared in new manner such that one can say that A has received from B the metabolic energy.

2. Energy would be conserved. I have also considered the interpretation that the total energy of the system associated with CD increases [K75] [L93]: since CD itself breaks Poincare invariance, it seems that one cannot exclude this. However, the Poincare invariance is realized at the level of moduli space for the positions of the either boundary of CD, and one can assume energy conservation. Even the wave functions at the boundary of CD can be taken to be

in the representations of Lorentz group acting as its isometries. Plane waves correspond to
wave functions in the moduli space for the boundary of CD keeping second boundary fixed.

3. To make this more precise one must define metabolic energy more precisely by introducing
   the hierarchy of Planck constants and the fact that the increase of h_{eff} of sub-system keeping
   other parameters constant increases it energy. Second law means that A tends to loose energy
   due to the decrease of h_{eff} for its sub-systems. This is true also for the time-reversed state
   but in opposite direction of geometric time so that with respect to standard direction of
   time the energy increases. This would provide extremely general purely thermodynamical
   mechanism of remote metabolism.

A model of protocell based on Pollack effect

I learned about extremely interesting Quanta Magazine article (`http://tinyurl.com/y34o784j`)
telling about findings related to water droplets as protocells able to perform chemical metabolism
as a transfer of molecules to exterior and back. See

The work is carried out by David Zwicker and collaborators at the Max Planck Institute
for the Physics of Complex Systems and the Max Planck Institute of Molecular Cell Biology and
Genetics, both in Dresden. The report about the work is published in Nature Physics.

In a simplified model for the droplets (P-granules in C-elegans cell is the real life example)
the proteins in droplet can be in two states: in state A the stay in droplet and do not get out but
can enter to the droplet from outside. In state B they can get out from droplet. To get into state
B energy such as sunlight would be required.

TGD suggests a concrete counterpart for the droplet as exclusion zones (EZs) induced by
energy feed such as radiation in water in Pollack effect. EZs are able remove inpurities from interior
in conflict with second law. TGD based explanation of the mystery is change of the arrow of time
induced by TGD counterpart of ordinary state function reduction in zero energy ontology (ZEO):
self-organization would be dissipation with reversed arrow of time at at the magnetic body (MB)
of system acting as master and forcing time reversed evolution at the level of ordinary bio-matter
serving as a slave.

TGD suggests for the model of protocell as droplet a realization as exclusion zone (EZ)
generated in Pollack effect.

1. The exclusion zones (EZs) discovered by Pollack [I147, I126, I22, I91, L23] (`http://tinyurl.com/oyhstc2`) behave just like this. TGD allows to build a model of the Pollack effect [L23]
   (`http://tinyurl.com/gwasd8o`). The formation of EZs requires water bounded by a gel
   phase and they are negatively charged. Their really strange feature is that they throw out
   impurities just like state B in the model: this seems to defy second law telling that gradients
   tend to disappear. This makes possible primitive chemical metabolism involving exchange of
   chemicals between droplet and exterior. Light signal initiating the transfer by providing the
   metabolic energy needed. Transfer would stop as light signal stops.

   In TGD inspired quantum biology EZs are in crucial role. For instance, cell is negatively
   charged as also DNA double strand. Interpretation as EZs is natural.

2. The explanation for the negative charge of EZ is that part of protons and possibly other ions
   go to magnetic flux tubes forming the magnetic body (MB) of the system [L64, L91] (`http://tinyurl.com/yyyk6fu8` and `http://tinyurl.com/yjhx9xp7`). Dark ions form phases
   with nonstandard value $h_{eff} = n \times h_0 > h$ of effective Planck constant as cyclotron Bose-
   Einstein condensates. This system has long length scale quantum coherence and serves as
   a master controlling bio-chemistry, which is in the role of slave. This forces the mysterious
   coherence of the ordinary bio-matter impossible in life-as-mere-chemistry approach.

3. MB could control chemical metabolism of the droplet by sending dark photons to the droplet
   transforming to bio-photons and generating EZ state in the droplet and initiating transfer
   of molecules to the outside. The transition reducing the value of h_{eff} at MB would bring
   protons back to EZ droplet and it would become normal again. Secpnd law would force the
   molecules from outside to diffuse back to the droplet.

4. There is still one hard problem to be solved. What causes the mysterious removal of impurities from EZ challenging second law? Here zero energy ontology (ZEO) comes in rescue [L92] (http://tinyurl.com/wd7sszo). In ZEO macroscopic quantum jump corresponding to ordinary state function reduction changes the arrow of time . This would occur to MB as EZ is formed. Second law holds still true but in reverse time direction. MB is the boss and forces time reversal also at the level of ordinary bio-matter. The usual diffusion of molecules to cell occurs but with reverse arrow of time and explains the mysterious removal of impurities observed by Pollack for EZs.

All biological self-assembly processes would use this mechanism. In fact, self-organization quite generally would be dissipation in reverse direction of time: this would explain self-assembly aspect of self-organization. The big quantum jumps would inducing change of the arrow of time would tend to increase of h_{eff} in statistical sense (h_{eff} is identifiable number theoretically essentially as the dimension of extension of rationals and bound to increase in statistical sense). This would correspond to the evolutionary aspect of self-organization [L51, L64]. The increase of h_{eff} requires energy since the energy of state increases with h_{eff} with other parameters kept constant. Energy feed is therefore needed. Dark matter n TGD sense would make itself visible in everyday life.

3.2.8 The mystery of replication

Replication is one of the deepest mysteries of biology. It is really something totally counterintuitive if cell is seen as a sack of water plus some chemicals. We have a lot facts about what happens in the replication at DNA level but how this miracle happens is a mystery. At cell level the situation gets even more complex.

Philospher thinks that behind the chemistry there might lurk a much simpler quantum dynamics and that chemistry only makes its best to mimic this deeper dynamics. Is biochemistry controlled by something? Does this something provide a template for the dynamics at chemical level? The idea about the presence of this something popped up already in the mystery of EEG. What could this something perhaps receiving sensory information from vertebrate brain and maybe providing feedback as control signals affecting also chemistry?

Now our brave philosopher attacks the length scale reductionism again. Isn't it quite too much to require that all these replications in different length scales would result as accidental "emergence" due to thermodynamical fluctuations? Could the dynamics be fractal with essentially same patterns - for instance replication - occurring in different scales. Could this dynamics be induced by what happens on this something.

Philosopher also suggests a concrete model for the controlling level: dark matter with large value of Planck constant $h_{eff}/h_0 = n$ at magnetic flux tubes and asks whether the conjectured dark realization of DNA in various scales performs the fundamental replication inducing in turn the biological replication in various scales as a mimicry? This would simplify the situation enormously but in totally different manner than length scale reductionism. Morphogenesis controlled by the hierarchy of dark realizations of genetic code would be the basic vision (see http://tinyurl.com/yalny39x). This would simplify the situation enormously but in totally different manner than length scale reductionism.

TGD suggests also a purely topological element involved with replication. Magnetic body (MB) could replicate [K88]. Replication would be like 3-vertex of Feynman diagram representing the decay of a particle to two particles. MB or part of it regarded as particle like entity splits into two. The incoming 4-surface and two outgoing 4-surfaces meet along 3-D surface common to all three. After that various molecules would self-organize around the resulting templates. This could happen also for the MB of dark DNA in replication and induce the bio-chemical part of replication.

3.2.9 Morphogenesis

The problem of structure formation in biology - morphogenesis - was put under the rug by most biologists after the emergence of genetics. Sheldrake [L9, I130] is one of those who have taken it seriously and has been labelled as a crackpot by mainstreamers (I have discussed Sheldrake's views from TGD point of view in [L9, L37]). One just assumes that the structures are there and

performs chemistry around these structures. This approach is very practical and has given an enormous amount of data but very little understanding.

In standard physics the description of spatial structures would be in terms of enhanced densities of biomolecules or of their gradients in some space-time region. This is the only possibility because the space-time of standard physics is topologically and geometrically utterly trivial. Empty Minkowski space is an excellent approximation for it.

What philosopher has to say about this? If space-time topology were topologically non-trivial, situation would change dramatically. Already Wheeler saw this possibility and in the biology inspired by TGD (for which Wheeler suggested its name) all structures correspond to structures of topologically non-trivial space-time identified as surface in certain 8-D space-time: space-time sheets, magnetic flux tubes, etc... The entire TGD inspired quantum biology relies on this vision. The structures that we see around us would represent the non-trivial topology of space-time surface.

All structures - including bio-molecules, membrane like structures, organelles, organs, ... - would be 4-D space-time surfaces. Again philosopher gets excited since this would reduce the notion of shape in biology to a precisely defined and testable geometrodynamics coupling to em fields.

General view about morphogenesis

The new view about space-time lead to a rather general view about morphogenesis.

1. The presence of the Kähler field (em field is sum of Kähler field and second term) makes possible flow equilibria such as cell membrane, which are not minimal surfaces. These surfaces can be closed and stationary making possible isolation from environment crucial for living organisms.

   Spherical soap bubble is a good analogy: it is not minimal surface as the soap films spanned by frames are. They look locally like saddle surfaces with opposite external curvatures in two orthogonal directions, this implies that they cannot be closed surfaces. Bubble is not possible without a pressure difference Δp between the interior and exterior of the bubble: the blowing of the soap bubble generates Δp, and means external energy feed analogous to metabolic energy feed.

   Δp is analogous to a non-vanishing voltage V over cell membrane. The electric field of cell membrane and the energy feed providing the energy of electric field as metabolic energy are essential for the stability. More generally, V would generalize to non-vanishing of energy momentum tensor of Kähler field with non-vanishing divergence serving as a correlate for the energy transfer between Kähler and volume (gravitational) degrees of freedom.

   This generalises to all morphologies, which correspond to closed surfaces. They necessarily involve both Kähler electric and magnetic fields coupling to the geometry to stabilize the morphology. This statement would give some content for the exaggerated claim that biology is nothing but electricity + Schrödinger equation that I heard during my first student year.

2. For instance, the presence of Kähler electric field can correspond to electric fields of cell membrane or along a part of body. If it is too weak, things go wrong in development. As was found decades ago, consciousness is lost if the electric field between frontal lobes and hindbrain gets too weak or has wrong direction [J24]. Cell dies if the membrane potential becomes zero and EEG disappears in death. Also microtubules have electric field along their axes essential for their existence.

   Michael Levin and his collaborators [I110, I111, I141] have discovered further fascinating connections between electric fields and morphogenesis. One of the discoveries is that the electric fields of the embryo are controlled by neurons of the still developing brain (see `http://tinyurl.com/y77fcc7r`). This conforms with the view that neurons and their MBs correspond to a higher level in the hierarchy than ordinary cells and there take care of control in longer scales. The MB of the developing brain would be the controller.

3. A non-trivial coupling (four-momentum transfer) between the volume and Kähler degrees of freedom requires that the energy momentum currents have opposite and non-vanishing

divergences. For the energy momentum tensor of ordinary Maxwell field the divergence is proportional to the contraction of Maxwell current and Maxwell field so that the current must be non-non-vanishing.

In TGD the energy momentum tensor is replaced with energy momentum current allowing to have well-defined notion of energy momentum and corresponding conservation laws. Now the divergence contains two terms. The first one is the contraction $Tr(T_K H^k)$ of energy momentum tensor T_K of Kähler action with the second fundamental form H^k: this term proportional to T_K is new. Second term is proportional to the contraction $j_K J \nabla h^k$ of the induced Kähler form J with Kähler current j_K and gradients ∇h^k of embedding space coordinates analogous the divergence of energy-momentum tensor $j^\beta F^\alpha_\beta$ in the case of ordinary Maxwell action. One expects both terms to be non-vanishing.

For the mere Kähler action, which I believed for decades to determine the preferred extremals, j_K is either vanishing or light-like. In presence of coupling it can be both non-vanishing and time-like. The realization that cosmological term is present was forced by the twistor lift of TGD whose existence is possible only for $H = M^4 \times CP_2$ [K114, L52].

4. The predicted stabilizing Kähler (and em) currents would naturally correspond to the DC currents flowing along the body in various scales discovered already by Becker [J113, J24] and found to be essential for the survival of the organism. In particular, Becker's DC currents are essential for the healing of wounds and in the regeneration of organs. In the first first aid stage of the healing DC currents are generated locally and after than central nervous system (CNS) takes care of the generation of the current (for TGD based discussion of Becker currents see [K88] (see http://tinyurl.com/ydg6okkk) or [K90]). Also this is easy to understand from the proposed stability criterion.

This picture is discussed quantitatively in the framework of the twistor lift TGD in [K73] [L67].

Is genetic code involved with morphogenesis?

The chemical realization of the genetic code tells virtually nothing about morphogenesis. Could morphogenesis emerge via a general self-organization process having no dependence on genetic code? For instance, cell membrane consists of two lipid layers and soap films emerge spontaneously, and do not involve chemical genetic code.

TGD strongly suggests that quantum theory of self-organization replaces non-equilibrium thermodynamics so that the increase of h_{eff} generating dark matter is crucial for all self-organization processes involving dark matter in TGD sense: there would be no sharp distinction between living and inanimate matter. Furthermore, Pollack effect suggests that the dark phases of water could realize dark proton representation of the genetic code. Also the realization in terms of dark photon triplets is possible. Could morphogenesis rely on non-chemical realization of genetic code in long length scales?

Remark: In TGD also ordinary nuclei correspond to nuclear strings. Could genetic code be realized even at this level?

3.2.10 Hen-or-egg questions of biology

Standard biology suffers from several hen-or-egg problems. Which came first: genes or metabolism? The problem is that genes require metabolism and metabolism requires genes! Genes-first leads to the vision about RNA world and metabolism-first to lipids world idea.

The emergence of basic biomolecules is the second problem. What selected these relatively few basic molecules from huge multitude of molecules? Again hen-or-egg problems emerge. Which came first: proteins or the translation machinery producing them from RNA? Did RNA arrive before proteins or did proteins and RNAs necessary for their transcription and translation machinery emerge first. One can argue that ribozymes served as catalysts for RNA replication but how RNAs managed to emerge without replication machinery involving ribozymes? What about DNA: did it emerge before RNA or could it have emerged from RNA? It seems that something extremely important is missing from the picture.

TGD predicts the existence of dark variants of basic biomolecules DNA, RNA, tRNA, and amino-acids (AAs). One can ask whether something very simple could be imagined by utilizing the potential provided by dark variants of bio-molecules present already from beginning and providing both genes and metabolism simultaneously.

One can start from a couple of observations which forced myself to clarify myself some aspects of TGD view and also to develop an alternative vision about prebiotic period.

1. Viruses are probable precedessors of cellular life. So called positive sense single stranded RNA (ssRNA) associated with viruses can form temporarily double strands and in this state replicate just like DNA (see `http://tinyurl.com/yc5f8b3t`). The resulting single stranded RNA can in turn be translated to proteins by using ribosomal machinery. RNA replication takes place in so called viral replication complexes associated with internal cell membranes, and is catalyzed by proteins produced by both virus and host cell.

   Could ribozyme molecules have catalyzed RNA replication during RNA era? For this option AA translation would have emerged later and the storage of genetic information to DNA only after that. There is however the question about the emergence of AAs and of course, DNA and RNA. Which selected just them from enormous variety of options.

2. Lipid membranes are formed by self-organization process from lipids and emerge spontaneously without the help of genetic machinery. It would be surprising if prebiotic life would not have utilized this possibility. This idea leads to the notion of lipid life as a precedessor of RNA life. In this scenario metabolism would have preceded genes (see `http://tinyurl.com/y7ehv8cq` and `http://tinyurl.com/y8nltb9e`). The basic objection against both genes-first and metabolism-first options is that they need each other!

Consider now the situation in TGD.

1. In TGD framework the dark variants of DNA, RNA, AA, and tRNA would provide the analogs of genes and all basic biomolecules. They would also provide a mechanism of metabolism in which energy feed by (say) solar radiation creates so called exclusion zones (EZs) of Pollack [L23] in water bounded by a hydrophilic substance. EZs are negatively charged regions of water giving rise to a potential gradient (analog of battery) storing chemically the energy provided by sunlight and the formation of these regions gives rise to dark nuclei at magnetic flux tubes with scaled down binding energy.

   When the p-adic length scale of these dark nuclei is liberated binding energy is liberated as metabolic energy so that metabolic energy feed giving basically rise to states with non-standard value $h_{eff}/h = n$ of Planck constant is possible. For instance, processes like protein folding and muscle contraction could correspond to this kind of reduction of h_{eff} liberating energy and also a transformation of dark protons to ordinary protons and disappearance of EZs.

   The cell interiors are negatively charged and this is presumably true for the interiors of lipid membranes in general and they would therefore correspond to EZs with part of protons at magnetic flux tubes as dark nuclei representing dark variants of basic biomolecules. Already this could have made possible metabolism, the chemical storage of metabolic energy to a potential gradient over the lipid membrane, and also the storing of the genetic information to dark variants of biomolecules at the magnetic flux tubes formed in Pollack effect.

2. In TGD framework biochemistry would have gradually learned to mimic dark variants of basic processes as a kind of shadow dynamics. Lipid membranes could have formed spontaneously in water already during prebiotic phase when only dark variants of DNA, RNA, AAs and tRNA, water, and lipids and some simple bio-molecules could have been present. The dark variants of replication, transcription and translation would have been present from the beginning and would still provide the templates for these processes at the level of biochemistry.

   Dark-dark pairing would rely on resonant frequency pairing by dark photons and dark-ordinary pairing to resonant energy pairing involving transformation of dark photon to ordinary photon. The direct pairing of basic biomolecules with their dark variants by resonance

mechanism could have led to their selection explaining the puzzle of why so few biomolecules survived.

This is in contrast with the usual view in which the emergence of proteins would have required the emergence of translation machinery in turn requiring enzymes as catalyzers so that one ends up with hen-or-egg question: which came first, the translation machinery or proteins. In RNA life option similar problem emerges since RNA replication must be catalyzed by ribozymes.

3. Gradually DNA, RNA, tRNA, and AA would have emerged by pairing with their dark variants by resonance mechanism. The presence of lipid membranes could have been crucial in catalyzing this pairing. Later ribozymes could have catalyzed RNA replication by the above mentioned mechanism during RNA era: note however that the process could be only a shadow of much simpler replication for dark DNA. One can even imagine membrane RNAs as analogs of membrane proteins serving as receptors giving rise to ionic channels. Note however that in TGD framework membrane proteins could have emerged very early via their pairing with dark AA associated with the membrane. These membrane proteins and their RNA counterparts could have evolved into transcription and translation machineries.

DNA molecules would have emerged through pairing with dark DNA molecules. The difference between deoxi-ribose and ribose would correspond to the difference between dark RNA and dark DNA manifesting as different cyclotron frequencies and energies making possible the resonant pairing for frequencies and energies. Proteins would have emerged as those proteins able to pair resonantly with dark variants of amino-acid sequences without any pre-existing translational machinery. It is difficult to say in which order the basic biomolecules would have emerged. They could have emerged even simultaneously by resonant pairing with their dark variants.

The FB post of Robert Stonjek (that I read much later than the previous text was written) told about a popular article in Phys Org (see this) about the modelling of unexpected findings related to muscle contraction [**?**]. The article is very interesting from the point of view of TGD inspired quantum biology (see for instance [L64, L122].

1. Muscle contraction requires energy. From the article one learns that the contraction is not actually well-understood. The interesting finding is that the rate of muscle contraction correlates with the rate of water flow through the muscle. As if the water flow would provide the energy needed by the contraction. How? This is not actually well-understood. This is only one example of the many failures of naive reductionism in recent biology.

2. In the muscle contraction, the flow of water involving these contracting flux tubes would liberate the energy needed by contraction and the process would be very fast. The water flowing through the muscle is a fuel carrying energy at its monopole flux tubs with $h_{eff} > h. The energy is used and water becomes ordinary. The rate of the flow correlates with the rate of contraction and w$

3. The interesting question is whether ATP-ADP mechanism loads the monopole flux tubes associated with water, say those carrying dark protons and associated with information molecules and providing a realization of genetic code, with energy. Second question is whether the ATP-ADP mechanism is a special case of this mechanism. I have indeed proposed that the very long monopole flux tubes associated with gravitational field of Earth with gravitational Planck constant $\hbar_{gr}$ or with the electric field of, say, Earth with electric Planck constant $\hbar_{em}$ could serve as temporary energy storages and contract in the process and liberate energy [L128].

3.2.11   How life began?

The central question of biology is "How life began?" and dark variants of biomolecules suggest not only a solution to various paradoxes but also a concrete answer to this question.

The transcription machinery for rRNA including ribozymes and mRNA coding for the proteins associated with ribosomes is central for the translation. The DNA coding for rRNA is associated with nucleolus (see `http://tinyurl.com/yavahwzt`) in the center of the nucleus.

1. After the emergence of the first ribosome the ribosomes of the already existing nucleus can take care of the translation of the ribosomal proteins. But how could the first ribosome emerge? This question leads to a paradox bringing in mind self-reference - the basic theme of Gödel-Escher-Bach of Douglas Hofstadter, perhaps the most fascinating and inspiring book I have ever read. The ribosomal proteins associated with the first ribosomes should have been translated using ribosome, which did not yet exist!

2. Could the translation of the first ribosomal proteins directly from the dark variants of these proteins solve the paradox? The idea of shadow dynamics induced by the pairing of basic biomolecules with their dark variants even allows to ask whether the replication, transcription, and translation could occur at dark level so that dark genes for ribosomes would be transcribed to dark ribosomal RNA and dark mRNA translated to dark AA associated with the ribosomes. These in turn would pair with ordinary ribosomal RNA and AA.

3. But what about dark variants of ribosomes? One can encounter the same paradox with them if they are needed for the translation. Could it be that dark variants of the ribosomes are not needed at all for the translation but would only give rise to ordinary ribosomes by the pairings basic biomolecules and their dark variants. Dark DNA would pair with dark mRNA, which pairs spontaneously with dark tRNA. Once the ordinary ribosomes are generated from the dark ribosomes by pairing, they could make the translation much faster.

4. There is however a problem. Both dark RNA and AA correspond to dark nuclear strings. Dark tRNA realized as nuclear string in the proposed manner does not have a decomposition to dark AA and dark RNA as ordinary tRNA has. The pairing of dark tRNA and dark mRNA should rise to dark AA and dark nuclear string - call it X - serving as the analog for the pairing of mRNA sequence with "RNAs" of tRNAs in the ordinary translation.

5. How to identify X? Could the translation be analogous to a reaction vertex in which dark mRNA and dark tRNA meet and give rise to dark AA and X? X cannot be completely trivial. Could X correspond to the dark DNA?! If so, the process would transcribe from dark DNA dark RNA and translate from dark RNA and dark tRNA AA and dark DNA. This would lead to an exponential growth of dark DNA and other dark variants of bio-molecules. This exponential growth would induce exponential growth of the basic bio-molecules by pairing. Life would have emerged! No RNA era or lipid era might be needed. All basic biomolecules or their precursors could emerge even simultaneously - presumably in presence of lipids - but this is not the only possibility.

One can take a more precise look at the situation and try to understand the emergence of bio-molecules and their basic reactions as shadows of the dark variants of bio-molecules appearing in dark particle reactions. The basic idea is that same dark reaction can give rise to several reactions of biomolecules if varying number of the external dark particles are paired with corresponding bio-molecules. Under what conditions this pairing could occur, is left an open question. Consider now the dark $2 \to 2$ reactions and possible reactions obtained by pairing of some particles.

1. The reaction

    DmRNA+DtRNA→ DAA + DDNA

    gives rise to translation mRNA+tRNA $\to$ AA if DDNA-DNA pairing does not occur in the final state but other dark particles are paired with the their ordinary variants. If only DmRNA-mRNA and DDNA-DNA pairings occur, the reaction gives the reversal mRNA $\to$ DNA of transription.

    It should be easy to check whether this is allowed by the tensor product decomposition for the group representations associated with dark proton triplets [L34]. Same applies to other reactions considered below.

    If the reaction is possible then also the reversal

    DAA + DDNA $\to$ DmRNA+DtRNA.
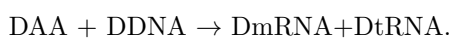
    can occur. If only DDNA-DNA and DmRNA-mRNA pairings occur this gives rise to transcription of DNA→ mRNA. Also reverse translation AA $\to$ mRNA is possible.

2. One can consider also the reaction

   DmRNA+DtRNA → DAA + DmRNA
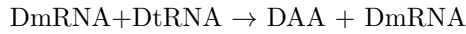
   is possible. If all pairings except DAA-AA pairing are present, the outcome is instead of translation the replication of mRNA such that the amino-acid in tRNA serves the role of catalyzer. I have considered the possibility that this process preceded the ordinary translation: in a phase transition increasing h_{eff} the roles of AA and RNA in tRNA would have changed [L69].

   If this reaction is possible then also its reversal

   DAA + DmRNA → DmRNA+DtRNA
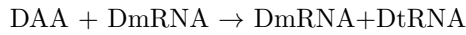
   is allowed. If all pairing except DmRNA-mRNA occur, this gives rise to AA +RNA → tRNA allowing to generate tRNA from AA and RNA (not quite RNA).

3. The replication of DNA strand would correspond at dark level to a formation of bound states by the reaction

   DDNA+DDNA→ DDNA $+_{bound}$ DDNA

   in which all particles are paired. The opening of DNA double strand would correspond to the reverse of this bound state formation.

These dark particle reactions behind the shadow dynamics of life should be describable by S-matrices, which one might call the S-matrix of life.

1. For instance for
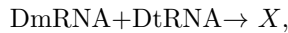
   DmRNA+DtRNA→ X,

   where X can be DmRNA+DtRNA (nothing happens - forward scattering) or DAA + DDNA and perhaps even DAA+DmRNA, one would have unitary S-matrix satisfying $SS^{dagger} = Id$ giving probability conservation as $\sum_n p_{m,n} = |S_{mn}|^2 = 1$ as a special case. Writing $S = 1+iT$ unitarity gives $i(T - T^{\dagger}) + TT^{dagger} = 0$ giving additional constraints besides probability conservation.

   For

   DmRNA+DtRNA→ DAA + DDNA
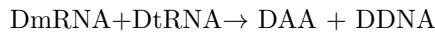
   the non-vanishing elements of T are only between pairs [(DmRNA,DtRNA), (DAA,DDNA)] for which mRNA pairs with tRNA and DNA codes for AA. Unitary matrix would be coded by amplitudes $t(AA, DNA_i(A))$ satisfying $\sum_i p_i(DAA) = p(DDNA + DAA)$, $p_i(AA) = |t(DAA, DDNA_i(A)|^2$. $p(DDNA+DAA)$ equals to $p(DDNA+DAA) = (1-p)Br(DDNA+DAA)$, where p is the probability that nothing happens (forward scattering) and $Br(DDNA+DAA)$ is the branching ratio to DDNA+DAA channel smaller than 1 if $Br(DDNA + DmRNA)$ is non-vanishing. The natural interpretation for $p_i(AA)$ would be as probability that DNA_i codes for it.

2. For the reverse reaction

   DAA + DDNA $rightarrow$ DmRNA+DtRNA
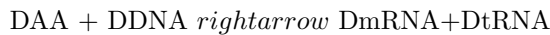
   it is natural to assume that DtRNA corresponds to any tRNA, which pairs with RNA. The AA associated with this tRNA is always the same but the counterpart of RNA can vary (wobbling). One can speak of the decomposition of dark genetic code to $DmRNA \rightarrow DtRNA \rightarrow DAA$ to a pair of codes mapping DmRNA to DtNRA and DtRNA to DAA [L65]. There is a set tRNA$_i$(mRNA) of tRNAs coding for given mRNA, and the probabilities $p_i(DmRNA)$ sum up to $p = \sum_i p_i(DmRNA) = (1 - p)Br(DmRNA + DtRNA)$, where p is the probability for forward scattering and $Br(DmRNA + DtRNA)$ is the branching fraction. The natural identification of $p_i(DmRNA)$ is as the probability that mRNA pairs with tRNA$_i$.

A possible weak point of the proposal is pairing: what are the conditions under which it occurs and are different pairing patterns possible. Possible second weak point is purely group theoretic: one should check whether which reactions are allowed by the tensor product decompositions for the states of dark proton triplets.

3.2.12 Homeostasis

Homeostasis means that system is able to preserve its flow equilibrium under changing conditions. This involves many-layered hierarchies of pairs of control signals with opposite effects so that the system stays in equilibrium. For instance, we could not stand without this control system as one can easily check by using non-living test body! For instance, in bio-chemical homeostasis the ratios of concentrations remain constant. It is not at all clear whether ordinary chemistry can explain homeostasis.

In zero energy ontology (ZEO) one can imagine very fundamental mechanism of homeostasis.

1. Zero energy states are pairs of ordinary 3-D states with members located at opposite boundaries of causal diamond (CD). Their total quantum numbers are opposite, which is only a way to say that conservation laws hold true. The space-time surfaces connecting the 3-surfaces are preferred extremals of the action principle.

   In quantum field theory this picture can be seen only as a book keeping trick and one assumes that space-time continues beyond causal diamond. There is however no need for this in TGD framework although it is natural to assume that there is some largest CD beyond which space-time surfaces do not continue. CDs form a hierarchy and sub-CDs of this CD can be connected by minimal surfaces, which are analogs of external particles. One obtains networks analogs to twistor Grassmannian diagrams.

2. Conscious entities (selves) correspond in ZEO to a sequences of state function reductions having interpretation as weak measurements, "small" state function reductions [L53]. In given weak measurement the members of the zero energy state at the passive boundary of CD are not affected: this is essentially Zeno effect associated with repeated measurements in ordinary quantum theory. The members of the state pairs at the active boundary of CD change and also the temporal distance between the tips of CD increases: this assigns a clock time to the experienced flow of time as sequence of state function reductions.

   Eventually it becomes impossible to find observables, whose measurement would leave the passive parts of the zero energy state invariant. First "big" state function reduction changing the roles of active and passive boundaries of CD takes place and time begins to run in opposite direction since the formerly passive boundary recedes away from the formerly active boundary which is now stationary. Self dies and re-incarnates with an opposite arrow of time. In TGD biology these two time-reversed selves are proposed to correspond to motor actions and sensory perceptions.

   Already Fantappie [J98] realized that two arrows of time seem to be present in living matter (consider only spontaneous assembly of bio-molecules as decay in opposite direction) and introduced the notion of syntropy as time-reversed entropy. For an observer with given arrow of time, a system with opposite arrow of time seems to break the second law. Temperature and concentrations gradients develop, system self-organizes.

3. These two quantal time evolutions with opposite arrows of time look very much like competing control signals in homeostasis. The 4-D conscious entities corresponding to control signals would have finite lifetime so that in their ensemble the effects of the signals with opposite arrows of time tend to compensate. This would give rise to homeostasis.

3.2.13 Evolution

I forgot perhaps the most important piece from the original text. Philosopher cannot avoid the question "What is evolution?"

In standard biology evolution is mystery. If one believes on standard thermodynamics, evolution is impossible by second law and the eventual heat death is unavoidable. Evolution means generation of structures and second law indeed states that all gradients die so that the finals state is totally uninteresting homogenous stuff.

I already mentioned the weird proposal that biology is just an enormous thermodynamical fluctuation. Boltzmann brain was indeed a kind of fad of pop physicists for some years ago. The idea - if you want to call it such - was that Boltzmann brains - and also ours - popped up from the

multiverse by a complete accident. One could even argue that this occurred only at planet Earth to make the claim more plausible. This is however not science anymore, this is just pure plain idiocy.

Philosopher asks questions and now the most obvious questions are following. Is evolution something much more general than biological evolution? Is evolution a basic aspect of physics as already cosmological evolution suggests? Is evolution "must", something completely unavoidable? What could force it?

The Universe governed by second law certainly does not allow evolution: just the contrary. Could the increase of entropy and increase of conscious information and development of cognition relate somehow? It has been argued by Jeremy England [I125] (see `http://tinyurl.com/o64rd7o`) that biological evolution involves increase of the rate of entropy production as any-one can see by just looking around. These two things are not the same but are they somehow related [L26] (see `http://tinyurl.com/zjp3bp6`).

Philosopher gets now childishly excited. We must just tolerate. Our philosopher already mentioned that p-adic physics as physics of cognition not only leads to a measure for conscious information - something very non-trivial - but to adelic physics fusing physics in various number fields [L50, L51]. Adeles form a hierarchy labelled by the dimension of the extension of rationals inducing the extension of p-adic number fields labelled by primes. This dimension corresponds to the effective value of Planck constant and the larger it is, the larger the scale of quantum coherence is.

This has been already said but now comes the basic point and philosopher gets really excited. Since the number of extensions of rationals with dimension larger than given integer n is finite and the number of those with dimension larger than n is infinite, this dimension is bound to increase in statistical sense in the sequence of state function reductions recreating the quantum Universe again and again. Evolution is unavoidable! This is like random work from origin upwards. The height from the origin unavoidably increases.

Even more, the total negentropy coming from various p-adic sectors turns out to be larger than the entropy coming from the real sector. The bad news - not actually a news - is that increase of this negentropy is accompanied by the increase of entropy: civilizations indeed have the bad habit of polluting their environments. The good news is that negentropy increases faster than entropy: for a trivial extension of rationals from which everything would have started, negentropy equals to entropy. But for more complex extensions it is larger.

3.2.14 Darwinian or neutral theory of evolution or something else?

I learned recetly that the so called neutral theory of evolution has been challenged by evidence for DNA selection (see `http://tinyurl.com/ybhyh6rc`). I must admit that I had no idea what neutral theory of evolution means. I had thought that Darwinian view based on random mutations and selection of the most adaptive ones is the dominating view. The debate has been about whether Darwinian or neutral theory of evolution is correct or is some new vision needed. This inspired a more precise formulation of how evolution at genetic level could take place in TGD Universe.

Darwinian and neutral theories of evolution

Darwinian and neutral theories of evolution and their variants represent two different views about evolution.

1. Adaptive evolution is the Darwinian view. Random mutations are generated and organisms with the most adaptive genome survive. One can of course argue that also recombination occurring during mitosis creating germ cells creates new genetic combinations and must be important for the evolution. Selection can be either negative (purifying) and eliminate the non-adaptive ones or positive favoring the reproduction of the adaptive ones.

   One can argue that notions like "fight for survival" and selection do not fit with the idea about organisms as basically inanimate matter having no goals. Also second law poses problems: no evolution should take place, just the opposite. Metabolic energy feed induces self-organization but by second law all gradients about which metabolic energy feed is an example, disappear.

2. Neutral evolution theory was proposed by Morita 50 years ago and gained a lot of support because of its simplicity. Point mutations for the codons of DNA would create alleles. Already in Darwinian evolution one knows that large fraction of mutations are neutral having not positive or negative effect of survival. Morita claims that all mutations are of this kind. There would be no "fight for survival" or selection.

   The so called genetic drift, which is completely random process is possible in small populations and can lead to counterpart of selection: it can happen that only single allele remains and is counterpart for the winner in selection. This is purely random and combinatorial effect and in physics one would not call it drift.

   The first objection is that if one has several isolated small populations, the outcomes are completely random so that in this sense there is no genetic drift. Furthermore, there is no reason why further mutations would not bring the disappeared alleles back. Second objection is that there would not be no genuine evolution - how one can speak about theory of evolution?

   Now the feed of experimental and empirical data is huge as compared to what it was 5 decades ago and it is now known that the neutral theory fails: for instance, varying patterns of evolution among species with different population sizes cannot be understood. It is also clear that selection and adaptions really occur so that Darwin was right.

3. The shortcomings of the neutral theory led Ohta to propose nearly neutral theory of evolution. Mutations can be slightly deleterious. For large populations this leads to a purging of slightly deleterious mutations. For small populations deleterious mutations are effectively neutral and lead to the genetic drift.

   There is however a further problem: why the rate of evolution varies as observed between different lineages of organisms.

4. One reason for fashionability was that the model was very simple and allowed to compute and predict. Only the size of the population and rate for the mutations is enough to predict the future in small populations. The predictions have been poor but this has not bothered the proponents of the neutral evolution theory.

   As an outsider I see this as a typical example of a fashionable idea: these have plagued theoretical particle physics for four decades now and led to a practically complete stagnation of the field via hegemony formation. Simple arguments show that the idea cannot be correct but have no effect.

    Article explains several related notions.

1. It has been possible to determine the mutation rates at the level of individual sites of genome since 2005. Only subset of mutations of say cancer cells are functionally important to cancer and they can be identified. This leads to a selection intensity as basic notion. This notion is expected to be very valuable for the attempts to find targeted cure of cancer.

2. Neutral theory of evolution assumes that only point mutations matter. Theory was therefore completely local at the level of genome - and certainly simple! Innocent outsider knowing a little bit about biology wonders why the recombination of maternal and paternal chromosomes in meiosis creating the chromosomes associated with germ cells are not regarded as important. This mechanism is non-local at the level of genome and would naturally lead to a selection at the level of individuals of the species. It has been indeed learned that the genetic variation and the rate of recombination in meiosis correlate in given region of genome. This sounds almost obvious to the innocent novice but had to be discovered experimentally.

   One can however still try to keep the neutral theory of evolution by assuming that recombination is completely random process and there is no selection and adaption - contrary to the experimental facts and the basic idea behind the notion of evolution. Recombination would bring only an additional complication.

   Besides the direct purifying selection and neutral drift there would be recombination creating differences in the levels of variation across the genomic landscape. This leads to the notion of genetic hitchiking. When beneficial alleles are closely linked to neighboring neutral mutations,

selection acts as a unit on them. One speaks about linked selection. Frequencies of neutral alleles are determined by more than genetic drift but one can speak of neutrality still. Linkage of hitchiker to allele - beneficial or not - is however random. Does genuine evolution takes place at all?

3. Most of the DNA is not expressed as proteins. It would not be surprising if this part of DNA could have important indirect role in gene expression or perhaps be expressed in some other manner - say electromagnetically. How important role this part of DNA has in evolution? There are also transposons inducing non-point like mutations of this part of DNA: what is their role. There also proposals that viruses, usually though to be a mere nuisance, could play decisive role in evolution by modifying the DNA of host cells.

4. It is now known that up to 80-85 per cent of human genome is probably affected by background selection. Moreover, height, skin color blood pressure are polygenic properties in the sense that hundreds or thousands of genes are acting in concert to determine these properties. This strongly suggests that point-like mutations cannot be responsible for evolution and not even recombinations are enough if random. A control of evolution in longer scales seems to be required. This of course relates to the basic problem of molecular biology: what gives rise to the coherence of living matter. Mere bio-chemistry cannot explain this. Something else perhaps controlling the bio-chemistry is needed.

TGD based view about evolution

One can start by criticizing the standard view.

1. Is the standard view (to the existent that such exists) about evolution consistent with second law? One can even ask whether standard view about thermodynamics assuming a fixed arrow of time is correct.

2. If mutations and more general changes of genome occur by pure change, can they really lead to a genuine evolution. The notions of selection and survival of fittest are notion, which do not conform with the view about evolution as mere standard physics. A probable motivation for neutral evolution theory has been the attempt to get rid of these notions: physicalism taken to extreme.

3. The reduction of life to bio-chemistry does not allow to understand the coherence of organisms.

4. One can also criticize the reduction of life to mere genetics.

   (a) Genetic dogma does not tell much about morphogenesis.

   (b) Is genetic determinism a realistic assumption? Clones of bacterium are know know to have personalities behaving differently under given conditions (see `http://tinyurl.com/us7fxlh`).

   (c) Most of the genome of the higher organisms consists of DNA not transcribed to RNA still interpreted as junk by some biologists. What about introns? Could there exists other forms of gene expression - say electromagnetic.

TGD based view about evolution can be seen as a response to these criticisms but actually developed from a proposal for a unification for fundamental interactions and from the generalization of quantum measurement theory leading to a theory of consciousness and generalization of quantum theory itself.

1. TGD leads to a new view about space-time and classical fields. In particular, many-sheeted space-time and magnetic body bring in new element changing dramatically the views about biology.

   The notion of Maxwellian fields is modified. Unlike in Maxwellian theory any system has field identity, field body, in particular magnetic body (MB) carrying dark matter n TGD sense and

in well-define sense at higher evolutionary level as compared to ordinary bio-matter. This expands the standard pairing organism-environment to a triple MB-organism-environment.

MB can be seen as the controlling intentional agent and its evolution would induce also the evolution of the ordinary bio-matter. MB carries dark matter as $h_{eff}/h_0 = n$ phases giving rise to macroscopic quantum coherence at level of MB. MB forces the ordinary bio-matter to behave coherently (not quantum coherently).

TGD leads also to a realization of genetic code at the level of dark analog of DNA represented as dark proton sequences [L75] - dark nuclei, which are now essential element of TGD based view about nuclear physics [L89]. Dark photons are essential for the communications between MB and ordinary bio-matter. Also dark photons would realize genetic code with codon represented as 3-chord consisting of 3 dark photons.

Genetic modification would take place at the level of magnetic flux tubes containing dark analog of DNA and induce changes of the ordinary genome, which would do its best to mimic dark genome. In particular, the recombination occurring during the meiosis would be induced by the reconnection of the flux tubes of dark genome.

2. Number theoretical vision about evolution deriving from the proposal that p-adic physics for various primes combining to what I call adelic physics is second needed element [L51]. Any system can be characterized by a extension of rationals defining its algebraic complexity. The dimension of extension identifiable in terms of the effective Planck constant $h_{eff}/h_0 = n$ defines evolutionary level as a kind of IQ. What is remarkable that n increases in statistical sense since the number extensions with n larger than that for given extension is infinitely larger than that of lower-dimensional extensions. Intelligent ones have larger scale of quantum coherence and thus coherence of bio-matter and survive. Evolution is directed process forced by number theory alone.

   Quantum jumps in the sense of ZEO tending to increase n occurring naturally in mitosis generating germ cells lead also to a more intelligent genomes. Point mutations could be seen something occurring at the level of ordinary matter rather than being induced by dark matter.

3. Zero energy ontology (ZEO) is behind the generalization of quantum measurement theory solving the basic problem of standard quantum measurement theory. There are two kinds of state function reductions. "Small" state function reductions (SSFRs) as analogs of weak measurements give rise to the life cycle of conscious entity self having so called causal diamond (CD) as a correlate. Under SSFRs the passive boundary of CD is unaffected as also members of state pairs at it: this gives rise to the "soul" as unchanging part of self.

   "Big" state function reductions (BSFRs) correspond to ordinary state function reductions. They change the arrow of time and one can say that self dies and re-incarnates with a reversed arrow of time. This applies in all scales since consciousness and cognition predicted to be universal. In BSFRs the value of h_{eff} increases in statistical sense and this gives rise to evolution also at the level of genome. The reversal of the arrow of time allows to see self-organization and metabolism as dissipation in non-standard time direction so that generalization of thermodynamics to allow both arrows of time allows to understand both self-organization and evolution.

What could happen in meiosis and fertilization?

A possible application would be TGD based model for meiosis and fertilization.

1. In meiosis BSFR for the dark proton sequences defining dark DNA could induce reconnections of parallel maternal and paternal dark proton flux tubes inducing recombination at the level of the ordinary genome.

2. The resulting germ chromosomes - or rather their dark variants realized in terms of dark proton sequences would have arrow of time opposite that of chromosomes. They would be in a dormant state analogous to sleep.

3. Fertilization involves the pairing of paternal and maternal germ chromosomes and looks almost like time reversal of meiosis. In the proposed picture it would indeed change the arrow of time for the germ chromosomes - wake up them. The sequence meiosis replication-meiosisI-division - meiosisII would correspond to 4 BSFRs leading to germ cells having dark genome as as time reversal of ordinary genome.

   Remark: One can ask whether also the passive strand of ordinary DNA has arrow of time opposite to that of the active strand.

Mutations do not add: global epithasis and the notion of dark DNA

The Quanta Magazine article "How Genetic Surprises Complicate the Old Doctrine of DNA" (`rebrand.ly/xhr95c4`) provides a lot of food for thought. Epistasis is the concept discussed. One has a reasonable empirical understanding of point mutations. Point mutations are however not independent as simple linear thinking would suggest. This gives rise to epistasis.

Two mutations with qualitatively similar effects can produce a mutation with an opposite effect. Poorly understood interactions between mutations exist and give rise to the epistasis. One might call these interactions non-linear in a lack of a better word. The proposal that has been developed is global epistasis [I51] (`rebrand.ly/9jkuylm`) suggesting that genes and even large units would tend to have like coherent units.

My own intuitive view of DNA is based on quantum coherence in DNA length scales predicted by the TGD based view of chemical DNA as a chemical "shadow" of what I call dark DNA.

Dark DNA is realized as sequences of dark protons at the monopole flux tubes of the magnetic body associated with the ordinary DNA. It relies on a universal realization of the genetic code based on a completely unique icosa-tetrahedral tessellation of hyperbolic 3-space (light-cone proper time constant 3-surface in Minkowski space M^4). Genetic code might be universal at the level of the magnetic body and biological realization(s!?) would be only of the many. This would make the Universe intelligent, conscious and evolving in all scales using the fundamental binary coded with a codon as a 6-qubit unit [L126].

Not only codons but also genes would be quantum coherent units interacting like particles. For instance, dark genes consisting of N dark codons (each with 3 dark protons) would emit 3N-photon as a single unit in communications based on 3N-resonance, which implies that identical dark genes can communicate with each and that the modulation of frequency scale as a message is coded to a sequence of resonance peaks analogous to a sequence nerve pulses. This is a quantum generalization of what occurs in radio communications. Even larger quantum coherent units can be considered.

This implies that mutations are not anymore independent as in the picture based on chemistry alone. Mutations could have profound effects on the communications by 3N-resonance and 3N frequency resonance is not anymore complete if one codon changes. Therefore the effects of two or more mutations on dark gene communications do not simply add up. This raises the hope that their interactions might be understood some day.

Phenotype is much more stable against point mutations of genotype as one might expect: Why?

Paul Kirsch sent an interesting link (`rebrand.ly/r7pdwdj`) to a genetics related article [I78] discussing the question how stably genotype determines the phenotype. The article proposed a number theoretic formula for the probability that a point mutation does not affect the phenotype. This probability is called robustness of the phenotype. The number theory involved is very different from that in the TGD framework and I do not understand the technical details.

One considers the correspondence between genotype and phenotype and point mutations in which code letter changes. The point mutations that do not affect the phenotype, are called neutral.

1. It is empirically found that robustness defined as the probability that a point mutation does not change a phenotype is orders of magnitudes higher than expected by assuming that this property is given by the probability that a random letter sequence gives rise to the phenotype. This is very natural since it makes possible steady evolution: quite few point

mutations change the phenotype.This requires that there are strong correlations between genes which can give rise to a given phenotype. The pool of allowed letter sequences is much smaller than the pool of all possible letter sequences.

2. It is argued that a certain number theoretical function gives a good estimate for this probability. I have no idea how they end up with this proposal. What this also suggests to me is that quite generally, the allowed genes are not random sequences of letters. There are correlations between them.

Could one understand these correlations by using the number theoretic view of biology proposed in the TGD framework? Consider first how general quantum states are constructed in number theoretical vision.

1. In the TGD framework, all quantum states are regarded as Galois singlets formed from dark particles. This universal mechanism for the formation of bound states is a number theoretic generalization of the notion of color confinement.

2. One obtains a hierarchy of Galois confined states. If one has Galois singlets at a given level one can deform them to non-singlets. One can also consider a larger extension in which the Galois group is larger and singlets cease to be singlets. One can however form Galois singlets of them at the next level. This is the general picture and applies to any physical state in number theoretical vision. In biology dark codons, dark genes, parts of the genome, perhaps even the genome, can belong to this hierarchy.

3. What does Galois singletness mean? The momentum components assignable to the Galois singlet as a bound state are Galois singlets and therefore ordinary integers when the momentum unit defined by causal diamond is used. The momenta of the particles forming the Galois singlet state are not Galois singlets: they have momentum components which are algebraic integers which can be complex. They are analogous to virtual particles. Galois singletness gives a large number of constraints: their number is 4 times (d-1), where d is the dimension of the extension.

This mechanism for the formation of bound states is universal and should apply also to codons and genes.

1. Free dark codons would be Galois singlets formed from 3 dark protons, which are not Galois singles. In gene, dark codons need not be Galois singlets anymore but the gene itself must be a Galois singlet and therefore defines a quantum coherent state analogous to hadron and behaving like a single unit in its interactions.

2. Galois singletness poses a constraint on the gene as a quantum state. Not any combination of dark codons is possible as a dark gene. In the momentum representation, the total momentum of genes as a many-codon state must have components, which are ordinary integers in the unit defined by the causal diamond. The momentum components assignable to codons are algebraic integers: they are analogous to virtual particles.

3.2.15 Maximally symmetric Universe, self-organized quanticality, and symmetry between order and disorder

The following comments were inspired by the Big Think article "A surprise new theory of everything involves the symmetry between order and disorder" (`https://rb.gy/vyh8g`). The article relates to the book "The language of symmetry" edited by Rattigan, Noble and Hatta (`https://rb.gy/h0d7n`).

Two ideas considered in the article, maximal symmetries and self-organized criticality, define two key principles of TGD. Also the third, rather paradoxical idea that symmetry breaking leads to a generation of symmetry, has a precise meaning in the TGD Universe.

Consider first the maximization of symmetries as a fundamental principle.

1. In the TGD framework, the fundamental principle determining physics as geometry is that the infinite-dimensional geometry of the "world of classical worlds" (WCW) exists mathematically. Physics is unique because of its mathematical existence and has maximal symmetries.

   Freed demonstrated that for the loop spaces this geometry is unique and indeed has an infinite-D group of isometries (Kac-Moody symmetries).

2. 4-D general coordinate invariance is essential in TGD and implies holography in reducing to a generalization of 2-D holomorphy to 4-D case, which in turn corresponds to 4-D quantum criticality.

   (a) The first guess would be that WCW consists of 3-D surfaces in $H = M_2^4$: $H = M_2^4$ is indeed unique by several mathematical arguments and also by standard model symmetries. 3-surface generalizes the notion of a point-like particle.

   (b) 4-D general coordinate invariance requires that a given 3-surface corresponds to a *nearly* unique 4-surface in H. This means holography, or equivalently, Bohr orbitology. WCW also has interpretation as a space of 4-D analogs of Bohr orbits. Quantum TGD becomes the analogue of wave mechanics in WCW.

      Note that in atomic physics this would mean the replacement of electrons configuration space E^3 with the space of its Bohr orbits: this would be fiber space over E^3 with fiber at given point consisting of Bohr orbits through it.

   Consider next self-organized criticality as a basic principle. In TGD quantum criticality is behind the analogous principle.

1. For 2-D systems conformal invariance implying holomorphy of string orbits extends to 4-D analog of holomorphy, which realizes quantum criticality in 4-D case. Holomorphy implies holography!

   Field equations reduce to a purely algebraic form, having no dependence on the coupling parameters of the action as long as it is general coordinate invariant and constructible using the induced geometry.

2. This happens outside 3-D and lower-D singularities. Space-time surface is a minimal surface, analog of a soap film spanned by frames. Minimal surface property is analog of massless field equations at field level and analog of massless geodesic property at particle level. The classical and quantum dynamics distinguishes between different actions only at the frames, which can however depend on action.

   To understand the self-organized quantum criticality (SOC), quantum TGD is required.

1. In Quantum TGD, wave functions of the ordinary wave mechanics are replaced with analogs of wave functions in WCW (WCW spinor fields as many-fermion states as WCW spinors) consisting of analogs of Bohr orbits. This forces a new ontology: I call it zero energy ontology (ZEO) forcing a new view of quantum measurement.

2. In state function reduction (SFR) this kind of superposition inside quantization volume (causal diamond (CD) is replaced with a new one, and also the size and other parameters characterizing the CD can change. The standard paradox of quantum measurement theory disappears.

3. There are two kinds of SFRs.

   (a) In small SFRs (SSFRs), the boundary of CD is stationary and states at it are not affected but the active boundary is shifted and CD tends to increase. The sequences of SSFRs correspond to Zeno effect, having no effect in standard QM, and give rise to a conscious entity, self, for which subjective time as sequence of SSFRs correlates with the increase of the distance between tips of CD.

(b) In big SFRs (BSFRs), the arrow of time changes so that the active boundary of the CD [L133] becomes passive and vice versa. BSFRS correspond to ordinary SFRs. BSFR means "death" of self and reincarnation with an opposite arrow of time. Even small perturbations can induce BSFR by affecting the set of the observables measured in SSFR: if the new set does not commute with those defining the passive states, BSFR unavoidably occurs.

(c) BSFRs give rise to SOC. Self lives at criticality against death! This is the analogy for the critical sandpile. As a consequence, the flow of consciousness of self has gaps with a distribution of gap durations. This is known for human consciousness [L137].

4. Paradoxically, this continual short term dying in BSFRs makes it possible for the system able to survive and correct behaviors. Self can also learn of avoidable behaviors by trial and error. Self can learn moral and ethical rules: do not do anything destroying quantum coherence! [L132]. Perhaps most of the learning is by this method.

Homeostasis is a basic implication [L142]. The system is at quantum criticality at the top of a hill and unstable. When it starts to fall down, it makes BSFR in some scale and changes the arrow of time and returns back near criticality. Self-organization, say spontaneous generation of molecules from their building bricks, can be understood as a time reversed dissipation.

The third topic discussed in the article relates to the paradoxical creation of symmetries by symmetry breaking. The emerging vision indeed is that symmetry breaking paradoxically leads to the emergence of a deeper symmetry. This is what the TGD view of the concrete realization of the isometries of WCW as symmetries of the physical system indeed predicts.

1. The half Virasoro algebra V with non-negative conformal weights serves as a simplified example. V contains an infinite set of sub-algebras V_k for which conformal weights are divisible by integer $k = 1, 2, ...$. One also obtains inclusion hierarchies $...V_{k(n)}V_{k(n+1)}...$ such that $k(n)$ divides $k(n+1)$, whose generalizations are very relevant to quantum TGD.

2. The ordinary realization of conformal symmetries is as a gauge symmetry for which the generators L_n, $n > 0$, annihilate the physical states. One can however generalize this and only assume that V_k and $[V_k, V]$ for some k annihilate the physical states. In this case, the generators L_n, $n < k$ do not annihilate the states and act as genuine symmetries. Gauge symmetries are broken but have transformed to genuine physical symmetries! This removes the paradox from the idea of emergence of symmetries by symmetry breaking!

These kinds of mathematical structures are the cornerstone of quantum TGD. Virasoro algebra is replaced with the isometry algebra of WCW and associated algebra but completely analogous conditions hold true. This mechanism would not hold true for the isometry algebra of WCW only.

Chapter 4

Can quantum biology really do without new physics?

4.1 Introduction

I was recently contacted bya friend with whom we have had several interesting discussions about consciousness and neuroscience. She sent several links related to certain aspects of quantum biology about which I had not been aware and these links inspired this article.

4.1.1 Background

One of the proposals of quantum biology is a quantum mechanism for the mysterious looking ability of birds and fishes to find back to the place, where they were born. It is believed that navigation involves detection of the inclination of the local magnetic field of Earth but not its direction as in the ordinary ordinary compass. The alternative option states that birds have an analog of compass in their brain. The challenge is to understand what is the mechanism making possible to get the information about magnetic field and how this information is transformed to a chemical signal and eventually to a pattern of nerve pulses. In TGD framework one can challenge the assumption that the magnetic field of Earth is what makes possible the navigation and even what the navigation means.

Quantum biologists try to solve the problem using standard quantum physics. The formidable looking problem is that the energy scale for magnetic energies is extremely small. In the magnetic field of Earth the magnetic interaction cyclotron energy for electron is by factor of order one million below the thermal energy. If one believes of quantum physics in its standard form, one should understand how it is possible to generate a signal making possible non-trivial chemical effects. The proposal that has gained widest acceptance is known has as radical-pair mechanism (RPM) [I42, I82, I103] and has raised hopes about circumvent this problem.

The answer to the question whether RPM works is very important from the point of view of TGD based explanation for macroscopic quantum effects in living matter since TGD based model involves new quantum physics via the hypothesis that dark matter corresponds to $h_{eff} = n \times h$ phases located at flux tubes of "magnetic body" (MB). If RPM fails, TGD based quantum biology would be the next natural trial (if science proceeded by trying first all options that fail).

I received links to several articles and list them here to help the interested reader. The following list is about phenomena involved.

- *Cryptochrome Mediates Light-Dependent Magnetosensitivity of Drosophila's Circadian Clock* by Yoshii *et al* [I80] (see `http://tinyurl.com/zvlmxp6`). Cryptochrome (CRY) (see `http://tinyurl.com/create.php`) has been proposed to be the photoreceptor being involved with both circadian rhythms and magnetosensitivity. In response to light CRY slows down the circadian clock and eventually leads to an arhythmic behavior.

  The response to magnetic fields in the range around 3 Gauss (6 times the strength of $B_E = .5$ Gauss) was found to be slowing down of the circadian clock. Clock response to magnetic field

was present in the presence of blue light but absent in red-light illumination. This suggests that the blue light is necessary for any response at all and that magnetic field affects the response.

This response could be understood as the effect as the activation of CRY by the external field but one can consider also more complex mechanisms. This finding is taken as a support for RPM, which predicts that the response depends on wave-length and strength of magnetic field.

- *Circadian and Geotactic Behaviors: Genetic Pleiotropy in Drosophila Melanogaster* by Clayton [I45] (see `http://tinyurl.com/j4vmr8c`) tells about correlation between circadian rhythms and gravitaxis (geotaxis). The following excerpt from the abstract gives some idea about the findings.

  Two of these genes, cryptochrome (CRY) and Pigment-dispersing-factor (PDF) are integral to the function of biological clocks. PDF plays a crucial role in maintaining free-running circadian periods. The CRY gene alters blue-light (< 420 nm) phototransduction which affects biological clocks, spatial orientation and taxis relative to gravity, magnetic fields, solar, lunar, and celestial radiation in several species. The CRY gene is involved in phase resetting (entrainment) of the circadian clock by blue light (< 420 nm).

  The following articles are about radical-pair mechanism.

- *Chemical magnetoreception in birds: The radical pair mechanism* by Rodgers and Hore [I42] (see `http://tinyurl.com/zsg4b95`).

  The abstract of the article is too long to be attached here but very informative and honestly tells the situation in the field. Abstract describes the basic problem that RPM must solve: the magnetic interaction energy of electron with the Earth's magnetic field is by 6 orders of magnitude too low. The abstract also mentions that with few exceptions RPM has been observed only in magnetic field intensities 10 Gauss- 10 Tesla. The exception would be avian compass and photosynthesis! The strength of 10 Gauss field is 50 times higher than the strength of Earth's magnetic field of $B_E \sim .5$ Gauss so that it is far from proven that RPM could be behind the avian chemical compass and unreasonable effectiveness of photosynthesis. Quantum biology might require new physics!

- *The Radical Pair Mechanism and the Avian Chemical Compass: Quantum Coherence and Entanglement* by Zhang *et al* [I82] (see `http://tinyurl.com/zvcguuz`).

  The abstract gives brief summary of the radical pair mechanism.

  We review the spin radical pair mechanism which is a promising explanation of avian navigation. This mechanism is based on the dependence of product yields on 1) the hyperfine interaction involving electron spins and neighboring nuclear spins and 2) the intensity and orientation of the geomagnetic field. This review describes the general scheme of chemical reactions involving radical pairs generated from singlet and triplet precursors; the spin dynamics of the radical pairs; and the magnetic field dependence of product yields caused by the radical pair mechanism. The main part of the review includes a description of the chemical compass in birds. We review: the general properties of the avian compass; the basic scheme of the radical pair mechanism; the reaction kinetics in cryptochrome; quantum coherence and entanglement in the avian compass; and the effects of noise. We believe that the quantum avian compass can play an important role in avian navigation and can also provide the foundation for a new generation of sensitive and selective magnetic-sensing nano-devices.

The basic idea of RPM is that the creation of electron pairs in states, which are quantum coherent superpositions of spin singlet and triplet states of two electrons, have hyperfine magnetic interactions with nuclear spins giving rise to anomalously large EPR and NMR signals. The small mass of electron is essential but still the problem in the case of avian

compass and photosynthesis is to understand how quantum coherence time can be long enough for large enough effect to result before the neutralization of the radical pair.

- *The radical-pair mechanism as a paradigm for the emerging science of quantum biology* by Kominis [I103] (see `http://tinyurl.com/glegn3u`).

  The radical-pair mechanism was introduced in the 1960's to explain anomalously large EPR and NMR signals in chemical reactions of organic molecules. It has evolved to the cornerstone of spin chemistry, the study of the effect electron and nuclear spins have on chemical reactions, with the avian magnetic compass mechanism and the photosynthetic reaction center dynamics being prominent biophysical manifestations of such effects. In recent years the RPM was shown to be an ideal biological system where the conceptual tools of quantum information science can be fruitfully applied. We will here review recent work making the case that the RPM is indeed a major driving force of the emerging field of quantum biology.

The claim RPM as a new paradigm could be motivated by the observation that radical pairs are formed also in the photosynthesis. As already found, the problem is that the magnetic field of Earth is only two percent of the minimal value of the magnetic field needed for RPM according to the laboratory experiments.

It is worth of emphasizing that RPM was introduced as early as 1960's to explain anomalously large EPR and NMR signals in chemical reactions of organic molecules. In TGD I ended up to the hypothesis h_{eff} hypothesis [?] and stronger $h_{eff} = h_{gr}$ hypothesis [K83] through the attempt to understand the observation of the pioneers of bio-electromagnetism (see for instance [J28, J35, J36] that ELF radiation in EEG frequency range has quantal looking effects on living matter at harmonics of cyclotron frequencies of biologically important ions in endogenous magnetic field $B_{end} = .2$ Gauss, which might correspond to the field strength at the flux tubes of Earth's magnetic field inside organism tuned to give rise to cyclotron frequencies ideal for biology. Cyclotron energies for ions are ridiculously small as compared to thermal energy and large h_{eff} seemed to be the only possible explanation. Could large h_{eff} effects been observed already around 1960's without realizing that new quantum physics is in question?

4.1.2 Some hints

It seems that several biological phenomena could use the same mechanism - RPM would be this mechanism if standard quantum theory is enough to understand these phenomena.

1. Magneto-sensitivity and circadian clock seem to be related: light-activated photoreceptors - cryptochromes (CRYs) serve also as magnetic sensors and the external magnetic fields slow down circadian rhythm.

2. Also gravitaxis that is the ability to move in direction parallel or opposite to the gradient of local gravitational field could relate to this mechanism. This requires that organism is able to perceive the gradient for the strength of the local gravitational field.

Blue light is necessary for the *chemical* magnetoreception and the establishment of circadian rhythm with period of order 24 hours. This is an important hint but leaves much open. Is just the presence of blue light enough for establishing to put the circadian clock ticking or does the periodic variant of the amount of blue light give rise to internal clock?

Blue light seems to have health effects. For instance, exposure to blue light at night time could be harmful to health (see `http://tinyurl.com/mggpafe`). In particular, too much blue light at night time could affect the circadian clock and too much blue light could lead to sleep disorders and various negative health effects such as several types of cancer (breast, prostate), diabetes, heart disease, and obesity. It is known that the amount of blue light correlates with melatonin secretion. Could the periodic variation of the intensity of blue light give rise to internal clock. Of course, there are very probably several cues used by internal clock (for instance, birds are not dead

matter behaving as robots!) and the variation of the intensity of blue light could be only one of them.

It has been also found (see `http://tinyurl.com/zvlmxp6`) that the presence of external magnetic fields in the range around 3 Gauss (Earth's magnetic field has nominal value .5 Gauss so that this field is 6 times stronger) tends to increase the period of the circadian clock. This would suggests that the clock in question does not use only the amount of blue light as a cue.

Before continuing it is good to list some abbreviations. Electromagnetic (em), Exclusion Zone (EZ), radical-pairing mechanism (RPM) are standard notions. At least for TGD inspired notions appear in the sequel: Topological Geometrodynamics (TGD), Strong form of Holography (SH), Zero Energy Ontology (ZEO), Causal Diamond (CD), Magnetic Body (MB), Biological Body (BB).

4.2 How to understand circadian clock, magneto-sensing and gravitaxis in TGD framework?

That photoreceptors responsible for circadian rhythms are involved with magnetoreception and the presence of blue light is necessary for magnetoreception are the basic challenges for any model. In RPM model this would follow from the assumption that blue light generates radical-pairs interacting with magnetic field but why just RPM should be crucial for photoreception? Why not some "easier" mechanism? Could bio-rhythms be due to some deeper quantum mechanism involving magnetic fields in an essential manner? Of course, RPM could still be involved but with non-standard value of Planck constant if TGD view is correct. Non-standard value of Planck constant could be involved even with the original anomalies associated with EPR and NMR.

I have described briefly what TGD is in the Appendix and recommend it for the reader before continuing.

4.2.1 Basic problems and basic principles

In Appendix I summarize what TGD and TGD inspired theory of quantum biology and quantum consciousness are. Here I just list the basic ideas relevant to the model considered. The basic elements of this model are MB following from the many-sheeted view about space-time and distinguishing between TGD and Maxwell's theory and the hierarchy of Planck constants $h_{eff} = n \times h$ possibly satisfying the additional constraint $h_{eff} = h_{gr}$ giving connection with quantum gravity which would allow macroscopic quantum phases in arbitrarily long length scales in TGD Universe.

The key principles and mechanism should be same as in TGD based model of quantum biology.

1. Magnetic body (MB) of living organism has a fractal structure corresponding to body parts labelled by corresponding cyclotron frequency scales. MB serves as an intentional agent receiving sensory data from biological body (BB) and controlling it. BB and MB must communicate and dark photons would make this possible. EEG would be one example of this communication and MB would receive by sensory data from cell membrane as dark generalized Josephson photons and control BB by dark cyclotron photons with the mediary of genome (at least) [K44, K95, K92]. EEG would generalize to other frequency ranges and generalized EEG rhythms could emerge in this manner. Dark phases of matter emerge at quantum criticality which is central element of the model. As a matter fact, TGD Universe is in well-defined sense quantum critical.

2. One cannot avoid the following questions. Is the avian navigation an automatic process. Could MB control it? Is conscious intelligence and volition involved so that the mechanism in question would be only a tool. Is the MB in question that of species or does the bird decide whether to follow the flux tubes of the personal MB connecting the bird to where it was born or in the horizontal direction defined by the MB of Earth? One must leave these questions open although the idea that the bird follows the horizontal flux tubes connecting it to the birth place (and assignable to the species?) is very attractive and would not favor the flux tubes of Earth which are not horizontal.

3. Quantum criticality allows several values of Planck constant are possible. The interpretation is in terms of long range as quantum fluctuations and quantum coherence in various length scales would have a universal explanation. Quantum criticality would be a general property of living matter and crucial also now.

4. The most economic assumption is that the mechanism is same as in the case of cell membrane identified as generalized Josephson junction coding nerve pulse sequences and membrane oscillations to EEG and in this manner sending sensory information to MB of the brain. I have indeed proposed long time ago that also biomolecules act as Josephson junctions. In fact, the cell membrane identified as generalized Josephson junction reduces microscopically to an array of generalized Josephson junctions defined by membrane proteins. For generalized Josephson junction Josephson energy $2eV$ for Cooper pair is replaced with its sum with the difference of cyclotron energies at different sides of the cell membrane. Electronic Cooper pairs would be naturally involved but also bosonic ions and Cooper pairs of fermionic ions can be considered for large values of h_{eff} and are indeed in crucial role in TGD based model of cell membrane.

   One of the first applications of TGD inspired biology was the explanation of so called Comorosan effect [I135, I41] in terms of bio-molecular Josephson junctions [K125]. The model assuming generalized Josephson junctions applies in the case of general biomolecules and suggests that there is universal 5 second Josephson time involved. This would require rather large value of h_{eff} (Josephson frequency is inversely proportional to $1/h_{eff}$) since the voltage involved is expected to be rather high in molecular length scales.

5. The basic assumption would be that blue light kicks the photoreceptor CRY to an excited state, which is quantum critical and generates large h_{eff} phases possibly satisfying also the $h_{eff} = h_{gr}$ condition with several values of h_{eff} at the flux tubes. Note that each flux tube carries only one kind of charged particle if it corresponds to a unique value of Planck constant. Dark charged particles are like books on shelves and the situation is just the opposite for the random dense soup of bio-molecules assumed in standard biochemistry.

   The basic prediction would be the dependence of the effect on strength of magnetic field as in case of RPM. The slowing down of the rhythm in presence of external B_E could be understood if the cyclotron energy difference in B_E between ground state and excited state changes so that the energy difference becomes smaller and flux tube in question has smaller value of B_{gal}: this could be due to the change of the net charge of the molecule.

   One should explain several phenomena using the same model.

1. Navigation involving perception of Earth's magnetic field, which possibly weakens to endogenous magnetic field which is 2/5 of it inside brain. A constraint to h_{eff} emerges from the condition that cyclotron frequency is in visible-UV range.

   If one demands $h_{eff} = h_{gr} = GM_D m/v_0$ one finds that dark mass M_D is of order $10^{-4} M_E$ and that it would correspond to a spherical layer of dark mass at distance of Moon. Skeptic of course begins to talk about Occam's razor. This layer is however natural in the model of dark matter. One could of course just speak about h_{eff} and forget $h_{gr} = h_{eff}$. The important point is that the notions introduced are not ad hoc notions but follow naturally from the very general assumptions of TGD as unification of fundamental interactions (see Appendix).

2. The challenge is to understand circadian rhythm with period about 24 hours. There is some evidence for the importance of the galactic magnetic fields for living matter. One such piece of evidence is the observation that the occurrence of tinnitus seems to appear rhythmically but with respect to galactic time. Galactic magnetic field of strength of about 1 nT could provide explanation. There is also earlier rather mysterious observation that precognition events seem to occur near galactic midday [J92]: this observation is of course not taken seriously by skeptics but deserves to be noticed. A possible test for the TGD based model is that the bio-clock actually measures sidereal rather than circadian time.

   The galactic cyclotron time for h_{gr} associated with Earth mass M_E is very natural if flux tubes carry Earth's gravitational field - is very near to 12 hours for galactic magnetic field a

fraction of nT. Cyclotron frequency would generate the biorhythm in manner analogous to that happening in the case of EEG. Only frequency scale would be much longer.

More precisely, according to the estimate of [K37, K38, K39, K40] the cyclotron time of DNA in B_{end} equal to 1 s is scaled up to 11.7 hours in B_{gal}=.63 nT. This estimate is obtained by accepting the $h_{eff} = h_{gr} = GMm/v_0$ hypothesis by identifying M as Earth's mass, and by assuming that the parameter $r = v_0/v_{rot,M}$ for Earth has the same value as for Sun. One has $v_0 \simeq 2^{-11}$ for Sun from the Bohr orbit model for the orbits of the 4 inner planets originally proposed by Nottale and v_{rot} is the rotational velocity of Sun.

It is needless to emphasize that this estimate involves uncertainties and that the value of B_{gal} assignable to the flux tubes has a distribution, which could be as wide as that for the energies of bio-photons. There are however good hopes of obtaining the circadian (or possibly sidereal) rhythm with natural choice of parameters.

3. The TGD description of gravitaxis should involve the flux tubes carrying gravitational flux of Earth. The same mechanism might be behind ordinary sensing of the gravitational acceleration. A good guess is that this magnetic field has same strength as galactic magnetic field B_{gal} to which Earth's mass would be associated via h_{gr}. The h_{eff} should be correspondingly higher to guarantee that dark cyclotron energy is in visible-UV range. The energy of blue light is good candidate now for exciting the quantum critical state in which this value of h_{eff} is realized.

   Gravitaxis would require the detection of the strength of Earth's gravitational field coded into the density of flux tubes parallel to it. The system should be able to detect the density of the flux tubes and this would occur naturally at quantum criticality via reconnections with these flux tubes and involving dark photons with energies in visible-UV range.

4. Two magnetic fields B_{end} and B_{gal} would be involved as also two values of Planck constant but cyclotron energies would be same and in bio-photon energy range. The two MBs should be able to communicate and one can consider the possibility that the spectrum of ionic cyclotron frequencies for $B_{end} = .2$ Gauss in EEG range corresponds to electronic cyclotron frequencies for a spectrum of values of G_{gal}. This assumption would fix the parameters of the model to very high degree. Interestingly, according to TGD based quantum model for hearing [K91], the audible frequencies would be coded by the thickness of flux tubes (or equivalently by the value of the magnetic field) and galactic flux tubes would give rise to a similar coding. Could hearing actually use the flux tubes of B_{gal}?

   If so, the ranges for audible frequencies and for bio-photon energies measured as number of octaves would be same. The range of frequencies audible for humans is about 10 octaves beginning from 20 Hz. Hence the spectrum of bio-photons should extend from say 1 eV to 10 keV. Dark IR photons are also predicted as a Josephson radiation from cell membrane with energies of photons of order $2eV \sim .1$ eV (Coulomb energy of Cooper pair assignable to cell membrane Josephson junction and roughly twice the thermal energy $E_{th} = 3T/2 \simeq .5$ eV at physiological temperature 330 K). I do not know whether IR energies are excluded as bio-photon energies and therefore whether the range of bio-photon frequencies could actually begin from .1 eV. If so, bio-photon energies would extend up to 1 keV.

   It is important to notice that the MB involved with navigation could be Earth's MB or galactic MB if its flux tubes correspond to personal MB of the organism connecting it to its birth place. It is quite possible that both MBs are be involved. One can imagine endless variety of models and the proposed model can be defended by the fact that it is based on the same mechanism as the quantum model for communications between BB and MB giving as special case the model of cell membrane.

4.2.2 Could circadian rhytms be analogous to EEG rhythms in TGD Universe?

In TGD Universe it is natural to think that the circadian rhythms and in fact all biorhythms - are basically analogous to EEG rhythms.

1. In TGD EEG frequencies would correspond basically to cyclotron frequencies in and endogenous magnetic field of .2 Gauss which is 2/5:th of Earth's magnetic field carrying dark particles (in TGD sense) having non-standard value $h_{eff} = n \times$.

2. The energies of cyclotron photons, which would be extremely small and much below thermal energy for the ordinary value of Planck constant, are scaled up by factor n by $E = h_{eff} \times f$ formula and can have non-trivial biological effects.

3. A further proposal is that the formulate $h_{eff} = h_{gr} = GMm/v_0$ holds true - at least for large values of h_{eff}. Here h_{gr} is gravitational Planck constant assignable to magnetic flux tubes mediating gravitational interaction, v_0 is a parameter with dimensions of velocity, m is the mass of the dark charged particle at the flux tubes, and M is some large mass.

   This formula guarantees that cyclotron energies proportional to $h_{gr}eB/m$ do not depend on the mass m of the charged particle for given charge. This in turn implies that dark cyclotron energy spectrum is universal. The hypothesis is that the transformation of dark photons to ordinary photons produces ordinary photons identifiable as bio-photons. If so the energies would be in visible-UV range and would dark photons could induce transitions of biomolecules and could serve as a biochemical control tool of the MB. If one accepts $h_{gr} = h_{eff}$ hypothesis for EEG, the value of the mass M should be around $M = M_D \sim 10^{-4} M_E$ for EEG. Using some additional cues given by TGD based view about how planets were condensed around dark matter blobs forming spherical cells or tubes around Sun or actually any astrophysical object, I have proposed a possible identification of M_D as a mass of spherical shell of dark matter assignable to Earth at the distance of Moon [K37, K38, K39, K40, K83]. Here skeptic of course has an excellent opportunity to introduce Occam's razor and I am of course ready to consider also the option that $h_{eff} = h_{gr}$ does not hold true at the flux tubes of B_{end}.

   What about the identification of circadian rhythms as cyclotron frequencies?

1. The general idea is that the flux tubes of both Earth's magnetic field and of galactic magnetic field can locally self-organize into complex braided structures serving defining the MBs of organisms, which would therefore be parts of much biffer organism. The flux tubes could connect living systems to each other and for instance, birds and fishes to their birth places.

2. The cyclotron time is much longer than for EEG rhythms and the natural guess is that the flux tubes of interstellar (galactic) magnetic field with field strength varying around the mean value $B_{gal} \sim 1$ nT are involved. The spectrum of cyclotron times would be of correct order of magnitude. $h_{gr} = h_{eff}$ hypothesis essential for the coupling of MB to biochemistry would be satisfied for $M = M_E$ in $h_{gr} = GMm/v_0$ so that one cannot assume that only dark mass contributes to the large mass in h_{gr}.

4.2.3 Trying to figure out the general mechanism

The details of the mechanism could be fixed by empirical input and using second assumption above as a guideline.

1. To my best understanding the role of RPM for avian chemical compass is speculative. RPM has been indeed observed only for magnetic fields stronger than 10 Gauss. Therefore it can be challenged. Even the notion of chemical compass is speculative.

2. The large cyclotron energies of dark charged particles would solve the problem caused by the extreme smallness of the electronic cyclotron energies - this could be the case even for ions. Radical pairs and electron pairs assigned with them could of course be present also in TGD inspired model. Even pairs of ions and bosonic ions.

3. In TGD context one could assume only spin singlet or triplet Cooper pairs with large value of $h_{eff} = h_{gr}$ in $B_{end} = 0.2$ Gauss. The existence of superconducting phase would require that Cooper pairs assignable to several CRY molecules reside at same flux tube pairs. This would make the process quantum coherent in longer scale.

4. Quantum criticality is needed and could be associated with the emergence of high Tc superconductivity [K89, K90] and would correspond to the transversal oscillations of magnetic flux tubes analogous to phonons assumed in ordinary superconductivity and also in RPM. They would lead to a transitions between flux tube pair with shape of flattened square and pair of pairs flux tubes of similar shaped induced by reconnection somewhere along flux tube pair. In transition to superconductivity long flattened square would stabilize. Above transition temperature shorter flattened square shapes would be stable and one would have super-conductivity but in short scale only.

5. Electron pairs would be analogous to Cooper pairs and if there is many of them in the system one would speak of super-conductivity. In TGD inspired quantum biology the electron pairs might be Cooper pairs with members at flux tubes, which are either parallel or antiparallel. Spin singlet and triplet Cooper pairs would correspond to flux tubes with opposite and parallel fluxes. The quantum coherent fluctuation between them assumed in the model does not look possible in TGD framework and is not needed.

6. Spin singlet Cooper pairs would result for closed flux tubes with the shape of flattened square. If one has pairs of this kind of flux tubes in parallel and close enough to each other, the second member of the Cooper pair could hop to second flux tube of the other flux tube pair so that members of the pair would be at flux tubes with parallel magnetic fields and form triplet. This kind of hopping could gives rise to the coherent quantum transitions between spin singlet and triplets and the ratio of singlets and triplets would be different from one in the final state and depend on the value of magnetic field and cause a chemical effect. This assumption need not be necessary for the model to work. The control by MB could be much more direct and take place at bio-photon energies.

7. Dark photons are somehow emitted and go to the flux tubes of B_{gal} in the case of circadian rhythm and gravitaxis. In the case of avian navigation the flux tubes could be those of B_{end} (B_E could be equal to B_{end} inside brain) or those of B_{gal}.

   The model of cell membrane as generalized Josephson junction with membrane proteins (channels and pumps) suggests a model in which the emission of dark photons could be generalized Josephson radiation with energy determined as difference of cyclotron energies plus ordinary Josephson energy. Dark Josephson photons going to the flux tubes of Earth equal to $B_{end} = 2B_E/5$ inside organism. from Blackman's experiments. This would give rise to magneto-detection of B_E. The mechanism would be exactly like the mechanism communicating sensory data to MB from cell membrane and allowing MB to control cell via genome using dark cyclotron photons. One can however consider also the replacement of B_{end} with B_{gal}.

One can imagine also the analog of RPM mechanism. In this case the dark electron pairs would fluctuate quantum coherently between spin singlet and triplet state and also interact with nuclear spins of the radical pair. The fusion of radical pair to a neutral state would destroy the quantum coherence. By a generalization of Uncertainty Principle cyclotron time would define the natural time scale and would be much longer than the time scale of coherence for RPM model. Maybe this could allow to test h_{eff} hypothesis.

4.2.4   More concrete model for the mechanism of magnetoreception and circadian rhythms

It is could to list some basic facts first.

1. Photopigment CRY must be excited by blue light needed to perceive magnetic field.

2. CRY interacts with magnetic field to establish the biorhythm.

3. External magnetic fields around 3 Gauss in presence of blue light slowed down the speed of the circadian clock.

What is the mechanism giving rise to the circadian clock? The naïve guess is that circadian rhythm corresponds to the periodic variation of the sensitivity to the external magnetic field determined by the amount of solar light. This certainly serves as a cue for the behavior and affects directly neuronal level but need not give rise to the fundamental biorhythm.

The simplest model does not explain why the circadian clock slows down (leading eventually to the loss of circadian rhythm) in external magnetic fields B_{ext} not too far from 3 Gauss- about 6 times the value of Earth's magnetic field? Hence it seems that the amount of blue light alone is not behind the clock mechanism but something more delicate is involved. The cyclotron frequencies assignable to weak external magnetic field (say B_{gal} whose flux tubes mediate gravitational interaction) as primary sources of circadian rhythms and controlled by B_{ext} somehow are suggested by the TGD inspired model of EEG.

The following picture suggests itself in TGD framework, where MB containing dark matter as large $h_{eff} = h_{gr}$ phases of ordinary matter controls biochemistry in quantum coherent manner in scales of even entire organism.

1. Basic entities are CRY molecule and its MB carrying some internal magnetic field B_{end} (to be not confused with $B_{end} \simeq .2$ Gauss) and having large h_{eff}. MB of galactic magnetic field B_{gal}: this in order to obtain cyclotron frequencies of order 24 hours for protons and ions. Magnetic flux tubes of galactic MB carrying cyclotron Bose-Einstein condensates for electrons, protons, ions each of them with $h_{eff} = h_{gr}$ proportional to the mass of charged particle in question. Different charged particles at their own flux tubes like books in the shelves of library.

2. Photons of blue light excite CRY. Excited CRY gradually returns to the ground state. This should lead to emission of dark cyclotron photons with cyclotron frequency of magnetic field involved for some charged particles at flux tubes? Transformation to dark cyclotron photons increasing hbar to $\hbar_{eff} = n \times \hbar$ takes place only at quantum criticality for the emitted photons. This might select the transitions corresponding to blue light.

3. The two MBs should interact by dark radiation at cyclotron frequencies. The excitations of CRY molecule by blue light would decay to ground state and emit dark photons with energy of blue light but with the cyclotron frequency for protons/ions of or order 24 hours. Magnetic field with the strength not too far from 1 nT, the strength of galactic magnetic field seems to be the most natural possibility.

4. CRY's MB must reconnect with that of galactic MB. Reconnection makes possible resonant interaction at multiples of cyclotron frequency. Large h_{eff} and biophoton hypothesis require that the energies involved are in visible-UV range. Blue light is in this range.

5. The resonant interaction would give rise to the perception of Earth's MB and make possible navigation: bird would fly to in the direction, where it perceives the flux tubes of Earth's MB.

6. Circadian rhythm would correspond to the galactic cyclotron frequency which would be same for all charged particles with the same charge by $h_{gr} = h_{eff}$ hypothesis implying that dark cyclotron photons have universal energy spectrum in the range of biophoton energies.

Why the external magnetic field with strength of order 3 Gauss has the slowing down effect? CRY should be able to couple to magnetic fields of this order of magnitude. The coupling should reduce the frequency of the emitted dark photons. It would seem that the frequency of dark photons emitted by CRY is reduced. This requires that the energy difference for its excited and ground states is reduced. If the ground state and excited state have different the difference of total energies contains the difference of cyclotron frequencies proportional to charge difference and magnetic field. If this difference is negative, its magnitude increases with B_{ext} so that the frequency of emitted photons reduced. Hence the CRY couples to flux tubes with weaker galactic magnetic field. This slows down the clock.

One can of course adopt a conservative attitude and consider a minimal modification of RPM by assuming quantum criticality and by replacing the Planck constant with $h_{eff} = n \times h$ eit $n \geq 50$. The excitation of CRY molecule responsible for the phenomena described could indeed

involve generation of radical pair in presence of blue light. The decay of RPM to neutral pair could produce photons transforming to dark photons at flux tubes? If so, the decoherence produced by the decay of RP would be compensated by coherence at the level of dark matter: negentropy maximization principle (NMP) [K70] would suggest this.

4.2.5   Gravitaxis and $h_{eff} = h_{gr}$ hypothesis

Gravitaxis might relate to the basic hypothesis about dark matter in TGD Universe as large h_{eff} phases: one would have $h_{eff} = h_{gr} = GMm/v_0$, v_0 is velocity parameter, m is some large mass, now presumably Earth's mass. This hypothesis is originally due to Nottale and plays key role in TGD inspired quantum biology.

What sensing a gradient in gravitational field could mean from the point of view of this hypothesis?

1. The simplest model assumes that the flux tubes along with gravitational interaction is mediated, are magnetic flux tubes with vanishing Kähler magnetic field but non-vanishing electromagnetic and Z^0 magnetic fields. These flux tubes would be vacuum extremals in absence of volume term in action. The volume term is proportional to cosmological constant and induced by the twistor lift of TGD [K49]. The flux tubes carrying magnetic monopole flux would be assigned to non-gravitational interactions: this distinction looks natural but does not seem to be necessary.

2. The density of the gravitational magnetic flux tubes must correlate with the average intensity of gravitational field at GRT limit of TGD. At fundamental level of many-sheeted space-time the detection of gravitational field strength would reduce to the detection of the density of these flux tubes. This detection would reduce to the same mechanism which makes possible magneto-sensitivity making possible avian navigation, biological clocks, and basic step of photosynthesis.

The overall conclusion is that TGD based quantum biology neatly unifies the description of several phenomena suggesting quantum biology in terms of magnetic body and dark matter as large h_{eff} phases. TGD based model is also needed since RPM proposal predicts effect which is at most 2 per cent of that needed to explain the observations.

4.3   TGD view about magneto-reception and circadian rhythm: few years later

Above is described the TGD based model for the findings related to magnetoreception and pace-keeper mechanism [L36] as it was for few years ago The model discussed also photo-taxis and gravi-taxis. The improved model discussed below relies on essentially the same elements but does not assume RPM as the mechanism producing nuclear spin polarization as an analog of compass.

4.3.1   Magneto-receptor as quantum compass

Magneto-reception could rely on quantum analog of compass consisting of flux tube containing dark cyclotron Bose-Einstein condensates. In the presence of external magnetic field - larger flux tube - Larmor radiation would be generated at cyclotron frequencies and energies scaled up by h_{eff}/h. These dark photons would transform to photons of blue light and be received by photo-receptors such as cryptochromes. The signal would be transformed to a chemical signal using the same basic mechanism as in photosynthesis without need to generate nuclear spin polarization. The same signal could also induce cyclotron transition of cyclotron Bose-Einstein condensates at magnetic flux tubes.

Why would blue light be needed?

1. The first explanation for the necessity of blue light could be that it kicks the cyclotron Bose-Einstein condensate from the ground state to excited state which them return to ground state by Larmor radiation. Blue light could induce transition between genuine transversal

cyclotron degrees of freedom or between longitudinal "particle-in-box" degrees of freedom. One can however argue that also in ground state spin reversing transition are possible if the particle has magnetic moment (for Cooper pair this is not the case).

2. Second explanation would be that blue light serves as metabolic energy needed to increase the value of h_{eff} [L64, L91]. If one assumes $\hbar_{eff} = \hbar_{gr} = GMm/v_0$ it is not clear whether the increase of h_{eff} is possible at gravitational flux tubes. Should one assume that the increase of h_{gr} means increase of the mass m of charged particles attached (by wormhole contacts, that is touching) with the gravitational flux tubes? m could correspond to mass of electron or biologically important ion - an integer valued spectrum $\hbar_{gr}$ in multiples of GMm_p/v_0 would result for ions.

4.3.2   The simplest pace-keeper mechanism does not explain the slowing down of the circadian rhythm

The simplest pace-keeper mechanism at fundamental level would correspond to a flux tube for which the orientation angle Θ of the external magnetic field with respect to the flux tube direction varies. Flux tube direction defines preferred quantization axis. The projection of the external magnetic field B to the direction of flux tube would vary and cause the cyclotron frequency scale to vary: one would have frequency modulation. The orthogonal component of B induces Larmor precession manifesting itself as cyclotron transitions at quantum level.

If there is a dark system with same value of h_{eff} receiving radiation with frequency near the cyclotron frequency, it develops a frequency resonance periodically if Θ varies periodically. Also the variation of the intensity of external magnetic field could be detected in this manner. Each resonance would correspond to a tick of the clock. The receiver could be also ordinary atom and in this case the tick would correspond to energy resonance. At magnetic side frequency resonance would be involved an at chemical side one would energy resonance.

What is important is that the period detected would directly correspond to the physical period.

There is however a problem involved. Why the irradiation by blue light would interfere with the pace-keeper mechanism? Why the clock would slow down and eventually cease to work?

1. Could the excitation of magnetic state make impossible the pace-keeper mechanism. If blue light increases the value of h_{eff}, energy resonance associated with the chemical aspect of pace-keeper function could be lost. The fraction of flux tubes for which this has happened would gradually increase during irradiation and this could spoil chemical pace-keeper mechanism.

2. But how to understand the slowing down of the clock? Why would the cyclotron period depending only the variation of external magnetic field increase? This is very difficult - if not impossible - to understand in a model assuming that the pace-maker rhythm equals to a rhythm assignable to the variation of external magnetic field if the measuring flux tube remains stationary.

4.3.3   A model based on cell membrane as a generalized Josephson junction (GJJ)

A more complex model could rely on cell membrane as GJJ [K92] [L4]. Now one would give up the simplest pace-maker mechanism and replace the bio-rhythm with generalized Josephson energy $E_{J,G}$ given as the sum $E_{J,G} = E_J + \Delta E_c(\hbar_{gr})$ of the ordinary Josephson energy $E_J = ZeV$ and the difference of cyclotron energies

$$\Delta E_c(h_{eff}) = \frac{\hbar_{eff}}{\hbar} \times \Delta E_c(\hbar) \qquad (4.3.1)$$

associated with the flux tubes at the two sides of the membrane and orthogonal to it. Generalized Josephson frequency $f_{G,J}$ would be given by

$$f_{J,G} = \frac{\Delta E_{J,G}}{\hbar_{eff}} = \Delta E_c(h) + \frac{f_J}{h_{eff}} \quad . \qquad (4.3.2)$$

1. The pace-maker rhythm could correspond to $f_{J,G}$ or its constant part coupling to dark flux tube by cyclotron resonance. This part should be rather slow (say 12 hours) and here one might consider specialized cells. In an analogy model as rotating gravitational pendulum $f_{J,G}$ would correspond to the rotation frequency Ω of the pendulum, perhaps near the critical value at which rotation transforms to oscillation. This transition could explain the loss of bio-rhythm. Irradiation by blue light should lead to a gradual reduction of Ω causing slowing down of the rotation. Same would happen also in the generation of nerve pulse.

   Note that for the Josephson radiation received at flux tubes of dark magnetic body carrying galactic magnetic field - the model for pace-make rhythm already discussed would apply. This clock would tick when the modulated generalized Josephson period $T_{J,G}$ has the value T_{12} about 12 hours.

2. $f_J = ZeV/\hbar_{gr}$ would be reduced by irradiation by blue light feeding metabolic energy inducing a phase transition increasing $\hbar_{gr}$. The naïve expectation is that the difference Δf_c of cyclotron frequencies would correspond to the dominating part of Ω about $T_{12} \sim 12$ hours.

   (a) For B_{end} option this turns out to be a good guess.

   (b) For B_{gal} option the cyclotron frequency would correspond to a cyclotron period about T_{12}. In this case the two contributions to $f_{G,J}$ should of the same same order determined by $1/T_{12}$. The cyclotron contribution depends on the sign of $n_1 - n_2$ so that Josephson and cyclotron contributions can have opposite signs and almost cancel: this could give rise to a period $T_{G,J} \geq\geq T_{12}$. Negative sign might be needed to fine-tune $T_{J,G}$ to T_{12}. Note that Josephson contribution behaves like $1/\hbar_{gr}$ so that the effect of blue light could be understood. Note also that below a critical value of $T_{G,J}$ the rotation of analog gravitational pendulum changes to vibration and the clock-function is lost. This is indeed observed after long enough irradiation.

3. There is still one objection. The flux tubes associated with cell membrane Josephson junctions should have radius of order $L(151) \sim 10$ nm. For acceptable values of h_{gr} this would however give huge cyclotron energy scale of order keV. The only option seems to be that one has slightly different values of $B = B_i$, $i = 1, 2$, at the flux tubes at the opposite sides of membrane. One would have

$$n_1 B_1 = n_2 B_2 \tag{4.3.3}$$

   in the ground state, where n_1 and n_2 are cyclotron quantum numbers so that the contribution of the difference of cyclotron energies to Josephson energy would vanish in ground state giving $E_{J,G} = ZeV/\hbar_{gr}$.

   In the replacement $B_i \to B_i + B$ with $B = B_{end}$ or $B = B_{gal}$, the cyclotron energy difference becomes $\Delta E_J = (n_1 - n_2)\hbar_{gr}(M_D)eB/m$ or $(n_1 - n_2)\hbar_{gr}(M_E)eB_{gal}/m$, where one has $M_D = 2 \times 10^{-4} M_E$. One has

$$f_{G,J} = (n_1 - n_2)f_c(B) + \frac{ZeV}{h_{gr}} \quad , \quad M = M_D \quad \text{or} \quad M = M_E \quad . \tag{4.3.4}$$

4. If the charged particle has magnetic moment, the difference between cyclotron energies involves spin contribution proportional to $\mu(B_1 - B_2)/m = \hbar_{gr}\mu B_1(n_2 - n_1)/n_2$. This contribution is small if n_i is large and $n_2 - n_1$ is small. Second option is that magnetic moment μ vanishes: this is the case if one as Cooper pairs with vanishing spin.

   The increase of $\hbar_{gr}$ locally induced by metabolic energy feed could induce also nerve pulse [K92] [L4].

1. The ground state of axons would correspond to a propagating soliton sequence nano-scopically analogous to a sequence of rotational gravitational penduli with constant phase difference. The local increase of $\hbar_{gr}$ would transform some rotating penduli to an oscillating mode and generate a local propagating perturbation identifiable as nerve pulse.

2. The increase of h_{gr} would correspond to a replacement of ions attached to gravitational flux tubes with heavier ones. This could relate to the flows of ions through cell membrane during nerve pulse. For instance, the replacement of electron with proton would reduce f_J by factor m_e/m_p. Nerve pulse would correspond to replacement of ions assignable to gravitational flux tubes with heavier ones.

4.3.4   Quantitative formulation of the model

Consider next the quantitative formulation of the model.

Basic parameters of the model

There are several parameters characterizing the new physics predicted by TGD and the model provides an excellent opportunity to get grasp on these parameters. In particular, the gravitational Planck constant $h_{gr} = GMm/V_0$ involves dark mass M and velocity parameter v_0 as parameters. The notion of magnetic field in TGD framework differs from its Maxwellian counterpart and magnetic field B_E of Earth can be decomposed to dark and ordinary part. Dark part consisting of monopole flux tubes could correspond to the endogenous magnetic field $B_{end} \simeq .2$ Gauss satisfying $B_{end} = 2B_E/5$ for $B_E = .5$ Gauss.

1. The parameters appearing in dark cyclotron energy

The condition $h_{eff} = h_{gr}$ would be satisfied. $\hbar_{gr} = GMm/v_0$ contains 3 parameters.

1. M denotes the dark mass expected to differ from M_E. There are several estimates for M.

   (a) $M = M_D = 2 \times 10^4$ was suggested by the model of fountain effect in super-fluidity [K37, K38, K39, K40]. While writing this article I learned that the "inner inner" core of Earth has mass $M_D/2 = 10^{-4}M_E$ if its density is the average density of Sun. The density of the inner core is certainly higher.

   (b) I have associated to Earth also a spherical layer with mass $M = .5 \times 10^{-4}M_E$ at distance of Moon. This mass has effect only at distances larger than distance of Moon but if one accepts the notion of magnetic body the effect could be real.

2. One can ask whether also the masses of various parts of Sun such as the mass of inner core with mass of inner inner core subtracted, mass of outer core, and mass of entire Sun could define dark masses with different value of v_0. Also sums of the masses could be involved. It turns out that the model requires masses $M = M_D$ for detection of B_{end} and $M = M_E$ for pace-keeper mode as dark masses. In the model of Nottale for planets as analogs of Bohr orbits one has $M = M_{Sun}$ [E2] [K104, K81, K83].

3. For the 4 inner planets of Sun one has $\beta_0 = v_0/c \simeq 2^{-11}$ and $\beta_0 = 2^{-11}/5$ for outer planets: $\beta_0 = 2^{-11}$ is the first guess also for Earth to be taken very cautiously. The value of β_0 could depend on the M_D but also a restricted universality can be considere. I have considered a model for β_0 [L56] [K18].

2. Strenghts of the magnetic fields

In TGD Universe Earth's magnetic field contains a monopole flux tube part - perhaps identifiable as the endogenous magnetic field $B_{end} = 2B_E/5$ - and non-monopole part.

1. B_E or part of it is measured. B_E has two parts in TGD Universe. Monopole part and non-monopole part. $B_{end} = 2B_E/5 = .2$ Gauss is suggested by the findings of Blackman and others and could corresponds to the monopole flux part of B_E. The nominal value of the Earth's magnetic field $B_E = .5$ Gauss.

2. B_{end} corresponds to a flux tube radius of about $L(169)$ then the minimal radius for flux tube would be about $L(163) \sim .640$ nm. The energies would be of the order of energies defined by membrane potential V. This looks natural at least because axonal radius is of order micrometer so that flux tubes with roughly half of the axonal radius could make sense.

   Monopole flux tube with a stronger magnetic field detecting B_E or B_{end} would be naturally associated with the magneto-receptor. This flux tube should has naturally radius 5 nm or 10 nm corresponding to $L(k)$, $k = 147$ or $k = 151$.

3. The estimate for the value of B_{gal} assigned with the pace-keeper mechanism is in the range $.5 - 1.9$ nT. For $B_{gal} = .5$ nT one has $B_{gal} = 2.5 \times 10^{-5} B_{end}$.

   Remark: Could either monopole or non-monopole part be parallel to rotation axis of Earth? Non-monopole part would be naturally parallel to rotation axis since it is generated by the rotation of outer core. Monopole part could correspond to the magnetic axis. The change of the direction of B_E would be induced by the change of the direction of the monopole part and induce currents changing the non-monopole part. Monopole part together with this refreshing mechanism would explain the maintenance B_E [L29]. The magnetic North pole is recently moving rather rapidly towards Siberia and the strength of B_E has been decreasing suggesting that the refreshing operation has been activated.

Quantitative tests

Does the proposed picture work quantitatively? Or is even the qualitative model correct as such.

   1. The values of the velocity parameters

1. Just as a blind guess I assumed first $\beta_0 \simeq 2^{-11}$ assigned to the 4 inner planets of Sun by Nottale [E2] [K104, K37, K38, K39, K40] (the assignment was based on the idea about near universality of β_0) and to the identification of dark mass as $M = M_D = 2 \times 10^{-4} M_E$ - the mass estimate for the "inner inner" core. This assignment gave a reasonable value for the universal cyclotron energy scale.

2. A possible justification for the guess comes from the behavior of the rotation velocity of particle in gravitational field of Earth behaving as $v = \sqrt{GMr}$ for circular orbit of radius r. At the surface of Earth with $r = R$ the rotational velocity of Earth

$$\beta_{0,E} \simeq \beta_{rot,R} 1.5 \times 10^{-6} = 3 \times 10^{-3} \beta_{0,Sun} \tag{4.3.5}$$

   would be first order of magnitude guess.

3. At the radius $r = 300$ km assignable to "inner inner" core one would have by scaling

$$\beta_{0,D} = \sqrt{R_E r} \times 2\beta_{0,E} \simeq 0.8 \times \beta_0 \quad . \tag{4.3.6}$$

   This is surprisingly near to β_0, which suggests that this parameter might be universal. One can test this hypothesis by looking what one obtains from this ansatz for the pace-maker model with $M = M_E$ and it turns out that nearly same value of β is needed.

4. One must bear in mind that also the value $\beta_{0,D} = \beta_0 = 2^{-11}$ is number theoretical favoured.

   Remark: The model for stars as analogs of blackhole like objects [L78] supports the view that the spectrum of β_0 comes in powers of 2 and corresponds to the spectrum of preferred p-adic length scales.

   2. Cyclotron and Josephson energy scales and corresponding frequencies

   Cyclotron and Josephson energy/frequency scales will be considered for three cases.

- Magneto-receptor mode

$$(B_{end}, M_D = 2 \times 10^{-4} M_E, \beta_{0,D} = \beta_0) \ , \quad .$$

- First variant of pace-keeper mode

$$(B_{gal}, M_E, \beta_{0,E}) \ ,$$

  where $\beta_{0,E} \simeq 3 \times 10^{-3} \beta_0$ is the rotational velocity at the surface of Earth.

- Second variant of pace-keeper mode

$$(B_{gal}, M_E, \beta_0) \ .$$

Universal cyclotron energy is given as a multiple $E_n = nE_c$, $E_c = ZeB/m_{eff}$. For $h_{eff} = h_{gr}$ cyclotron energies are universal having no dependence on the mass of the charged particle. The interpretation is in terms of Equivalence Principle. One has

$$E_c = \hbar \frac{ZeB}{m_{eff}} \ , \tag{4.3.7}$$

where one has

$$m_{eff} = \frac{\hbar \beta_{0,D}}{GM_D} = \frac{2\hbar \beta_{0,D}}{r_S} = \beta_{0,D} \times 1.24 \ eV \ . \tag{4.3.8}$$

Note that this value is for $M_D = 2 \times 10^{-4} M_E$. For $M_D \to M_E$ m_{eff} scales to $m_{eff} = .5 \times 10^{-4} m_{eff} = \beta_{0,D} \times 2.48 \times 10^{-4}$ eV for $M_D \to M_E$ applying for B_{gal}.

1. For $(B_{end}, M = M_D, \beta_{0,D} = \beta_0 = 2^{-11})$ mode this gives the estimate

   $$E_c \simeq 2 \ eV \ ,$$

   Note that E_c scale is considerably higher than E_J scale about .06 eV in magneto-receptor mode. One has $f_J/f_c = E_J/E_c = .03$.

   Cyclotron frequencies of biologically important ions in B_{end} are in EEG range 1-100 Hz (DNA has on the average $f_c = 1$ Hz). One has for $f_c(e, p, Fe^{++}) = (6 \times 10^5, 300, 10)$ Hz and $f_J(e, p, Fe^{++}) = (18 \times 10^3, 9, .3)$ Hz.

2. For $(B_{gal}, M = M_E, \beta_{0,E} = 3 \times 10^{-3} \beta_0$ mode one has $E_c = .13$ eV, which is above thermal threshold and roughly the energy $2eV$ of Cooper pair for cell membrane with voltage $.06eV$. One has $f_J/f_c = E_J/E_c \simeq .06/.13 \simeq .46 \leq 1$ and $T_J/T_c \simeq 2.2$.

   This option looks rather reasonable. In particular the effect of blue light increases $\hbar_{gr}$ and reduces f_J slowing down the circadian rhythm and can also cause the transition in which the $f_{G,J}$ becomes critical and the rotation of the analog pendulum transforms to oscillation and circadian rhythm is lost.

3. For $(B_{gal}, M = M_E, \beta_0)$ mode one would obtain

   $$E_c = 4 \times 10^{-4} \ eV \ ,$$

   which is below thermal threshold. $E_{G,J}$ would be however above thermal threshold. One has $f_J/f_c = E_J/E_c \simeq 150$ and $T_J/T_c = 1/150$. This option is not attractive.

A comment about the special role of DNA molecules is in order. DNA molecules are charged carrying charge of -1 units per nucleotide and -2 units per nucleotide pair of double strand.

1. For B_{end} the cyclotron frequency of DNA nucleotide would be about 1 Hz on the average and for fixed h_{eff} would not depend much on the length of DNA since DNA has constant Z/m ratio. Also cyclotron energy would be constant for fixed h_{eff}. For single nucleotide the cyclotron frequency would be same as for any ion for $B_{gal} = .5$ nT and equal to $f_c = 4 \times 10^4$ s to be compared to $T_{12} = 4.3 \times 10^4$ s.

2. For $h \to h_{gr}$ the situation changes. $f_{J,G}$ would behave like $a + b/N$, N the number of nucleotides. $E_{J,G}$ would behave like $aN + b$

Trying to build a more general view

The proposed picture is rather general and there is a temptation to generalize it further. The question whether there might be other dark masses besides M_E and M_D perhaps assignable to structures of Earth was already briefly considered. One can also ask about the spectrum of magnetic fields and whether also other structures bounded by double membrane (as a matter of fact, also single layered membrane might allow GJJs) could be possible.

1. What about p-adically scaled variants of magnetic fields?

The model discussed involves only 2 magnetic fields: B_{end} and B_{gal}, and one can expect that also other magnetic field strengths might be important. p-Adic length scale hypothesis suggests scale hierarchy of magnetic field strengths.

B_{end} corresponds to $k = 169$ defining p-adic length scale $L(169) = 5$ μm. This size scale is by factor 2 longer than the scale $L(167)$ assignable with cell nucleus. DNA is coiled and there is temptation to assign with the coiling the Gaussian Mersenne primes $M_{G,k} = 2^k - 1$. $k = 151, 157, 163, 167$: the existence of this Gaussian Mersennes is a number-theoretical miracle. Magnetic fields

The natural scaling for B_{end} assignable to the flux tubes with radius $L(k)$ would be $B_{end}(k) = 2^{169-k} B_{end}$. cyclotron frequencies for B_{end} correspond to cyclotron frequencies in the EEG and the additional p-adic length scales would give rise to scaled up variants of EEG possibly assignable to these smaller structures. Also larger flux tubes can be considered. $B_{gal} \simeq B_{end}(185)$ would also give rise to the counterpart of EEG which scaled up variants of resonance frequencies

$$f_{G,J} = 2^{169-k} f_c(ion, B_{end}) + f_J(\hbar) \frac{\hbar}{h_{gr}} \quad . \tag{4.3.9}$$

Could different values of B_{end} correspond to different modes for GJJ and cell? For $B_{end}(169)$ $f_{J,G}$ corresponds to EEG spectrum assigned to vertebrates having nervous system and nerve pulse activity having in TGD framework interpretation as manner to connect flux tubes assignable to axons to communication channels along which dark photons can propagate and mediate the message. Nerve pulse patterns would also generate generalized Josephson radiation communicating information to MB.

Could $B_{end}(k)$, $k \leq 169$, correspond to scaled up variants of EEG spectrum assignable to invertebrates? In this case the nerve pulse propagation would be missing but Josephson but localized analogs of nerve pulses involving the transformation of rotational motion to vibrational motion for the pendulum analog of Josephson junction would be possible.

2. Music and magnetic fields

The assumption that the values of B_{end} come in octaves is of course too strong. TGD based model for hearing and music experience [K91] leads to the proposal that the notes of scale correspond to cyclotron frequencies assignable to specific values of B_{end} and that each p-adic length scale would define its own octave.

Specific note of the scale identifiable as a rational multiple $f = rf_0$, $1 \leq r \leq 2$, of the fundamental frequency f_0 of the octave would correspond to a specific strength $B_{end}(r, k)$. This assumption is reasonable since in the adelic vision [L51] rationals correspond to the lowest evolutionary level. For GJJ the formula for $B_{end}(r)$ characterizing the note rf_0 associated with rational $1 \leq r = p/q \leq 2$ would be $fG, J = rf_0 = \frac{1}{m_{eff}} ZeB_{end}(r) + f_J(\hbar_{gr})$ giving

$$eB_{end}(r) = \frac{m_{eff}}{Z} \times (rf_0 - f_J[\hbar]\frac{m_{eff}}{m}) \quad , \quad m_{eff} = \frac{\hbar v_0}{GM} = \frac{2\hbar v_0}{r_S} \quad . \tag{4.3.10}$$

The appearance of Schwartschild radius in formula relate to music is not something that one might expect! Note that $m \propto A$ holds true for ions. The condition $f_0 \geq f_J(\hbar)\frac{m_{eff}}{m}$ seems necessary.

   3. Other membrane bounded structures

   Quite generally, bio-structures with sizes between cell membrane thickness and cell size could be characterized by the scales $L(k)$, $k \in \{151, 157, 163, 167\}$ equal to $[10, 80, 640, 2500]$ nm. Could there exist besides cell and nuclear membrane also other membrane structures giving rise to GJJs?

   Most viruses have radius varying from 10 to 125-200 nm and could correspond to $k = 151, 157$ and possibly other values of $k \in \{151, 159\}$. The largest viruses have radius 250 nm and length about 350-500 nm. Filoviruses have diameter about 80 nm (radius would correspond to $L(155)$) and length of 1400 nm. Viruses are contained by capsides consisting of identical proteins and can have lipid envelope derived from the host membrane. Maybe viruses utilize the GJJs of the host membrane.

   Chloroplasts (`http://tinyurl.com/ycthk562`) and mitochondria (`http://tinyurl.com/oh5qrob`) are structures surrounded by double cell membrane: the inter-membrane space (`http://tinyurl.com/ums7uyx`) is 10-20 nm thick suggesting total thickness 20-30 nm. This could correspond to $L(152)$. Could chloroplasts and mitochondria define GJJs in scale $L(152)$.

   Remark: Nucleolus (see `http://tinyurl.com/yavahwzt`) inside cell nucleus has diameter 2.5 μm corresponding to $L(167)$ but is not surrounded by membrane. It is however possible that flux tubes of $B_{end}(167)$ accompany it.

   Endoplasmic reticulum (ER) (`http://tinyurl.com/ybjmjykb`) is 2-layered structure with thickness of cell size scale.

1. The layers have thickness 2 μm and having 1 μm empty region between. The total thickness is 5 μm, which corresponds to $L(169)$ assignable to B_{end}. One of the first proposals inspired by p-adic length scale hypothesis in biology was that ER could give rise to the analog of cell membrane. This structure would be naturally accompanied by flux sheet of $B_{end}(169) \equiv B_{end}$ (cell membrane would be accompanied by cylindrical flux sheet of $B_{end}(169) \equiv B_{end}$).

2. Could one assign transversal flux tubes of thickness $L(169)$ with ER possibly measuring the value of magnetic field. Could the measured magnetic field be $B_{end}(169)$ associated with the flux sheet? This would allow to get rid of the condition $n_1B_1 = n_2B_2$ for the magnetic fields at the two sides of cell membrane with order of magnitude $B_{end}(151)$. The problem is that intuitively compass needle should carry magnetic field stronger than the detected field.

3. B_{gal} is a more natural candidate for the magnetic field detected by ER. B_{gal} would correspond to rather slow cyclotron rhythms. The cyclotron frequency for electron would be scaled down by B_{gal}/B_{end} from 6×10^5 Hz to 15 Hz. ER would live slow life as compared to cell membranes - maybe it corresponds to our conscious life.

4. Interestingly, the experiments of Blackman [J28] and others involved irradiation of vertebrate brain with harmonics of 15 Hz frequency. The explanation of the findings in terms of cyclotron radiation led to the identification in terms of cyclotron frequencies of Ca^{++} ion in $B_{end} = .2$ Gauss. Could there be a communication between these two levels at the cyclotron frequencies of Ca^{++}? The communication could take place by GJR emitted by dark electron Cooper pairs at endoplasmic reticulum and absorbed GJJs of cell membranes carrying $B_{end}(151)$. Could this explain the very special role of Ca^{++} ions in biology (see `http://tinyurl.com/w9o29xa`)?

   The objection is that the dark photon energies are different for B_{end} and B_{gal}: ~ 2 eV and about $\sim .1$ eV respectively. Energy conservation allows the decay of dark B_{end} photon to a bunch of about 20 dark B_{gal} photons, which are identical. ZEO allows the time reversal of this process. The bunch of identical 20 dark photons is analogous to a Bose-Einstein condensate behaving like single particle so that one has effectively 2-vertex also now in accordance with the hypothesis that all transformations changing h_{eff} occur at single particle level. I have

indeed proposed two processes changing the value of h_{eff}: decaying to a BE condensate would preserve frequency but not energy for single quantum and transformation of say dark photon to bio-photon would preserve energy but not frequency.

4.4   Appendix: What TGD is?

Since the purpose is to see the representations through TGD lense it is polite to first to tell to the reader what TGD is. The reader interested in details can find them for instance in [K124].

4.4.1   Why TGD?

The first question is "Why TGD?". The attempt to answer this question requires overall view about the recent state of theoretical physics.

Obviously standard physics plagued by some problems. These problems are deeply rooted in basic philosophical - one might even say ideological - assumptions which boil down to -isms like reductionism, materialism, determinism, and locality.

Thermodynamics, special relativity, and general relativity involve also postulates, which can be questioned. In thermodynamics second law in its recent form and the assumption about fixed arrow of thermodynamical time can be questions since it is hard to understand biological evolution in this framework. Clearly, the relationship between the geometric time of physics and experienced time is poorly understood. In general relativity the beautiful symmetries of special relativity are in principle lost and by Noether's theorem this means also the loss of classical conservation laws, even the definitions of energy and momentum are in principle lost. In quantum physics the basic problem is that the non-determinism of quantum measurement theory is in conflict with the determinism of Schrödinger equation.

Standard model is believed to summarize the recent understanding of physics. The attempts to extrapolate physics beyond standard model are based on naïve length scale reductionism and have products Grand Unified Theories (GUTs), supersymmetric gauge theories (SUSYs). The attempts to include gravitation under same theoretical umbrella with electroweak and strong interactions has led to super-string models and M-theory. These programs have not been successful, and the recent dead end culminating in the landscape problem of super string theories and M-theory could have its origins in the basic ontological assumptions about the nature of space-time and quantum.

4.4.2   TGD and GRT

The new view about space-time as 4-D surface in certain fixed 8-D space-time is the starting point motivated by the above mentioned energy problem of general relativity and means in certain sense fusion of the basic ideas of special and general relativities.

The higher-dimensional space-time is 8-D $H = M^4 \times CP_2$: empty Minkowski space M^4 of special relativity with points replaced by 4-D CP_2 (complex projective space of 4 real dimensions). The symmetries of special relativity are preserved but lifted to the level of H so that classical conserved quantities like energy exist. CP_2 in turns codes in its geometry the standard model symmetries and quantum numbers and its spinor connection codes for classical electroweak gauge fields. Their projections to space-time surface are dynamical. Also classical color fields can be understood. These geometrized fields are expressible only in terms of four CP_2 coordinates and cannot as such directly correspond to those of standard model. How standard model emerges as a limit of TGD will discussed below.

Rather recently [K49] I have discussed twistor lift of TGD replacing space-times with the twistor spaces and H with the product of twistor spaces of M^4 and CP_2, which are unique as 4-D spaces in the sense that they have twistor spaces with Kähler structure making possible to lift the Kähler action to 6-D one. The theory dimensionally reduced to a 4-D theory containing cosmological constant and gravitational constant as additional constants besides CP_2 radius and Kähler coupling strength.

4.4.3 TGD and string models

TGD can be also seen as a generararalization of hadronic string model or of superstring models by replacing strings with 3-D surfaces and 10-D space-time with 8-D $M^4 \times CP_2$. 3-space as we experience it corresponds to a large 3-surface to which smaller 3-surfaces are glued by wormhole contacts. These smaller 3-surfaces we would interpret as physical objects with shape and size and when they are really small, we call them elementary particles. We would directly see this extremely complex space-time geometry. This geometry has fractal hierarchical structure: 3-surfaces glued to larger 3-surfaces glued to....

As a matter fact, string world sheets and what I call partonic 2-surfaces in 4-D space-time regarded as space-time surface turn out to be fundamental objects of also TGD forced by very general principles such as well-definedness of em charge and strong form of holography (SH) implied by strong form of general coordinate invariance [K123]. SH states that information given at these 2-surfaces allows to deduce information about quantum states and classical dynamics: effective 2-dimensionality in the sense of information theory would be in question.

4.4.4 TGD based ontology

TGD forces to dramatically generalize the ontology of standard model and GRT.

1. The new view about space-time differs radically from that of GRT. Space-time surfaces are topologically non-trivial in all scales. They have typically finite size and obey size scale hierarchy. One can glue space-time sheets to larger space-time sheets to get a fractal scale hierarchy with sheets glued to larger sheets by wormhole contacts and having interpretation as correates for physical objects.

   Second key difference is that space-time surfaces can have also regions with Euclidian signature of the induced metric - time and space are geometrically in the same role. Wormhole contacts are this kind of regions and serve as building bricks of elementary particles and are identifiable as lines of generalized scattering diagrams.

2. A new view about classical fields emerges distinguishing TGD from Maxwell's theory. One can say that each physical object has field identity - field body consisting of space-time sheets. The notion of magnetic body (MB) turns out to be central in TGD inspired biology and adds MB to the pair organism-environment as a third member. The communications from BB involve classical radiation fields: EEG is one example of this communication from the brain to the MB of brain. The size scale of MB is typically considerably larger than that of BB: even of order Earth size scale or even larger. MB makes possible remote mental interactions and could be behind the morphic fields of Sheldrake.

3. How TGD relates to GRT and standard model? The basic idea is that the sheets of many-sheeted space-time obeying extremely simple physics (only 4 analogs of field variables plus SH realized by preferred extremal property implying effective 2-dimensionality of dynamics) are lumped together and identified as GRT space-time differing slightly from flat M^4.

   The deviation comes in the following manner. The deviations of the induced metric for space-time sheets from M^4 metric (empty space metric) are summed up to give GRT gravitational field as deviation from M^4 metric. Induced gauge potentials known once space-time surface is known are summed up in the same manner to give the gauge potentials of standard model. This because test particle experiences the sums of various induced fields associated with space-time sheets. Ordinary linear superposition is replaced at fundamental level with the set theoretic union for space-time sheets.

4. The hierarchy of Planck constants $h_{eff} = n \times h$ was originally motivated by certain strange findings in neuroscience about effects of ELF em fields on vertebrate brain [K88, K86]. First it was postulated that dark matter corresponds to phases of ordinary matter with $h_{eff} = n \times h$ having certain special kind of space-time surfaces (singular n-sheeted covering spaces) as correlates. Later it turned that these phases are actually predicted by basic TGD: in TGD framework Planck constants is for single space-time sheet h and only effectively $h_{eff} = n \times h$ but at QFT limit one can say that $h_{eff} = n \times h$ is strictly true.

Later the view about dark matter as evolved and according to the recent view dark matter would emerge at quantum criticality (perhaps even at ordinary criticality) and would be a correlate for long range quantum fluctuations and long range quantum coherence. Various quantal length scales are indeed typically scaled up by n. This suggests that biosystems are quantum coherent and quantum critical because MB contains dark matter.

MB containing dark matter would serve as intentional agent receiving sensory data from BB and controlling BB. EEG and its generalizations to various frequency ranges based on dark photons would be the tool for this. The dark cyclotron photons assignable to given charged particle would have very specific value of h_{eff} guaranteeing that cyclotron energy scale does not depend on particle mass and would be in the range of biophoton energies (visible and UV). Biophotons would result in the phase transition $h_{eff} \rightarrow h$. Also dark photons in IR range (Josephson photons assignable to cell membranes) are predicted.

Biochemistry would not be enough to understand the biology. MB and its "motor actions" would be crucial for understandind bio-catalysis, in particular the miraculous property of biomolecules to find each other in the molecular crowd.

5. Zero energy ontology (ZEO) is a further new piece of TGD ontology. In standard ontology the state of system at fixed value of time characterize the time evolution of the system. Classically the state is typically characterized by particle positions and velocities and by values of say Maxwellian fields and their time derivatives. Field equations in principle allow to deduce the time evolution from these.

   In ZEO one introduces causal diamond (CD). CD is intersection of future and past directed light-cones (Penrose diagram) with points replaced by CP_2. CDs are assumed to form a fractal scale hierarchy. CD has two light-like boundaries: "future" and "past" boundary. Light-likeness means that 3-D M^4 projection of given boundary correspond to a sphere expanding with light-velocity.

   Physical states are replaced with zero energy states analogous to physical events consisting of initial and final states. Initial/final state can be assigned to 3-D intersections of space-time surfaces with the "future"/"past" boundary of CD. ZEO is consistent with the crossing symmetry of quantum field theories and with the conservation laws. It is however extremely flexible since any zero energy state is in principle achievable by a sequence of quantum jumps. The analog of ordinary positive energy can be assigned with either "future" or "past" boundary and the arrow of time is different for these states. ZEO leads to a quantum measurement theory allowing to circuvemtn the basic problem of standard quantum measurement theory due to the non-determinism of state function reduction contra determinism of unitary time evolution.

6. p-Adic and adelic physics are further new ontological elements of TGD. p-Adic numbers are generalizations of real numbers, and there are infinite number of p-adic number fields for each prime $p = 2, 3, 5, ...$ I ended up with p-adic physics almost accidently by playing with p-adic generalization of thermodynamics and finding that p-adic thermodynamics can reproduce elementary particle masses with minimal assumptions and thus replaced Higgs mechanism with more fundamental theory. The properties of p-adic number led soon to the proposal that p-adic number fields are correlates for cognition and imagination. Much later this led to the unification of real physics and various p-adic physics in terms of adelic physics fusing all these number fields to a bigger structure.

   Why p-adic physics is so nice that one can talk about p-adic embedding space and space-time surfaces as kind of cognitive representations of real space-time surfaces. In particular, SH allows to assign p-adic space-time surface to given set of string world sheets and partonic 2-surfaces as preferred extremal but no necessary to real one. All imaginations cannot be realized!

   Also p-adic generalization of Shannon entropy makes sense but it can be negative. One can say that entanglement carries negative p-adic entropy - positive negentropy - although real entropy is non-negative. The interpretation is in terms of conscious information naturally assignable to cognition.

4.4.5   TGD, quantum measurement theory, and consciousness

TGD inspired theory of consciousness can be seen as quantum measurement theory in ZEO. Observer as an outsider becomes a part of physical system. Observer does not cause state function reductions but as a concious entity is a sequence of state functions on same boundary of CD - generalized Zeno effect.

1. The maximization of negentropy gain in state function reduction becomes the basic variational principle of consciousness theory consistent with second law which applies at the level of ensembles and is closely related to the growth of real entanglement entropy. I refer to this principle as Negentropy Maximization Principle (NMP).

2. In ZEO state function reduction can take place to either boundary of CD. In a sequence of reductions to a fixed boundary the boundary itself remains fixed as also the states at it - possibly entangled with those at the opposite boundary. This boundary is referred to as "passive". The second - "active" - boundary drifts farther away from the passive boundary and the states at it change. Each step can be regarded as time localization localizing the active boundary of CD.

   Self corresponds to this sequence of state function reductions. The permanent part of self - "soul" - corresponds to the unchanging part of self and changing part corresponds to consciousness determined byt sensory input. In particular, the experience about flow of time corresponds to the drift of the active boundary of CD farther away. Self is a generalized Zeno effect.

3. Eventually NMP forces the first reduction to the opposite boundary to occur. This is the counterpart of the usual large and non-deterministic quantum jump assignable to quantum measurement. Self dies and re-incarnates as time reversed self since the CD starts to increase in size in opposite time direction. This prediction has rather radical implications.

   Some of the implications deserve to be noticed.

1. One ends up with a new view about time. Geometric time as fourth space-time coordinate (or time coordinate as distance between the tips of CD) is not same as subjective time defined by a sequence of state function reductions. The consciousness experience associated with each reduction has the changing components with contents coming from the active boundary so that subjective time is mapped to discrete clock time.

2. Selves having hierarchy of CDs as embedding space correlate form a hierarchy. Subself is assumed to be experienced as mental image and subsubselves as kind of average sub-subself so that self is not drowned to microscopic information. Subconscious corresponds to conscious sub-sub-... -selves. We are ourselves mental images of some higher level self and the hierarchy continues ad infinitum with entire Universe at the top.

Part II

THE NOTION OF MAGNETIC BODY AND BIO-SUPERCONDUCTIVITY

Chapter 5

Magnetic Sensory Canvas Hypothesis

5.1 Introduction

There are very general objections against the idea that the ultimate sensory representations are inside brain. For instance, any computer scientist, unless informed about materialistic dogmas, would argue that the processing of the sensory data must be separated from its representation. How this could occur if sensory and other representations are realized inside brain, is however difficult to see. The classical experiments of Libet relating to the active and passive aspects of conscious experience [J115, J52, J22] provide a strong empirical support for the view that signals from central nervous system (CNS) spend.3-.5 seconds to propagate somewhere else. If the propagation occurs with the velocity of light, the distance in question is measured using the circumference of the Earth as a natural unit.

5.1.1 Sensory Canvas Hypothesis

In TGD approach these objections lead to the view that the magnetic flux tube structures associated with the central nervous system (CNS) could define a hierarchy of sensory, symbolic, and cognitive representations outside brain with magnetic flux quanta of the magnetic bodies serving as the canvas to which place coding by magnetic frequency generates sub-selves (mental images about "simple feeling of existence") and associates with them various sensory qualia and symbolic and cognitive features by quantum entanglement. Thus brain could be much like a RAM memory containing a collection of features in random order and the ordering would be induced only by the sensory map to the magnetic sensory canvas. Are our sensory representations at the magnetic flux tubes of Earth's magnetic field or are personal magnetic bodies needed? Since space travellers experience the world very much like us and have survived, the most plausible conclusion is that the magnetic sensory canvas is personal. This conclusion is also supported by the fact that the value of the magnetic field explaining the harmonics of 15 Hz as Ca^{++} cyclotron frequencies is.2 Gauss rather than.5 Gauss.

5.1.2 Why The World Is Not Experienced To Rotate As Head Rotates?

The question which originally led to the notion of the sensory magnetic canvas was "Why the world is not experienced to rotate as head rotates?". If one assumes that sensory representations are completely inside the cortex and that the positions of various visual mental images in the visual cortex remain fixed with respect to cortex as is done in the standard neuroscience, the entire sensory representation rotates thus with the head and one could argue that the world is experienced to rotate.

If one accepts the sensory magnetic sensory canvas hypothesis situation changes. Assuming that

1. the objects of the perceptive field induce sensory mental images (sub-selves) already at the level of sensory organs (in particular, retinas) and representations at corresponding magnetic bodies;

2. these mental images, being self-organization patterns, whose boundaries are determined by the gradients of illumination, do not rotate as the head or eye rotates;

3. the points of the retina correspond to fixed points of the visual cortex in topographic way;

4. the projections to the sensory magnetic canvas from the visual cortex occur orthogonally;

one can answer the question. Note that the personal sensory magnetic body is fixed with respect to head and rotates with it whereas the representation projected to it and defining a self-organization pattern does not. In other words, magnetic body acts like a canvas.

MEs define this sensory projection and EEG MEs correspond to our level in this hierarchy of projections. The sizes of these sensory selves are of order ME sizes ($L(EEG) = c/f(EEG)$) and thus or order Earth size at least. Thus TGD based view about sensory and other representations is a diametrical opposite of the standard view in which sensory representations are miniatures.

Some comments about terminology are in order. Sensory representations involve besides the primary sensory qualia the symbolic representations constructed by brain giving meaning for the sensory input. I will use also the phrase "cognitive representation". Space-time correlates for cognitive representations are tentatively identified as p-adic space-time sheets coinciding with real space-time sheets in resolution defined by some cutoff length scale: in general the intersection with real space-time sheets is discrete set of rational points common to reals and p-adic number fields. p-Adic space-time sheets are also identified as correlates for intentions and the realization of intention as action is tentatively identified as a quantum jump replacing p-adic space-time sheet with a real one in such a way that conservation laws are satisfied.

5.1.3 Model For The Sensory Representations

The construction of a more detailed model is based on the following assumptions.

1. Sensory qualia are at the level of primary sensory organs having their own magnetic bodies and entangled with the cognitive and symbolic representations of the perceptive field in brain in turn entangled with the points of the sensory magnetic canvas. The entanglement between primary sensory organs and brain and TGD based view about long term memory resolves the basic objections against this view, and one can understand the differences between sensory experience, imagination, dreams, and hallucinations and various strange phenomena like synesthesia, Anton's syndrome, and blind sight.

2. Second essential element is the mirror mechanism of long term memories. To remember something in the geometric past at temporal distance T is to look at a magnetic mirror with length $L = cT/2$. At quantum level quantum entanglement is involved and means sharing of mental images between recent me and the me of the geometric past (or some other self responsible for the memory representations). This requires that magnetic flux tubes involved with long term memories have astrophysical lengths with light year being the natural length unit. For magnetic fields this indeed makes sense. This picture is of course dramatically over-simplified. A more realistic model of long term episodal and declarative memories in which the magnetic body uses time mirror mechanism by sending entangling negative energy ME to the brain making possible sharing of mental images. From brain negative energy MEs are time reflected back as positive energy MEs and are possibly amplified. Positive energy MEs can give rise to classically communicated declarative memories. This means that the distance along a flux tube of the personal magnetic body codes for the temporal distance to geometric past.

3. The already mentioned findings of Libet about strange causal anomalies related to the passive aspects of consciousness lead to the conclusion that sensory experiences are geometric memories of the personal magnetic body in time scale of.3-.5 seconds about what happens in at the level of material body. Libet's findings about active aspects of consciousness in turn

allow to conclude that also motor activity must involve time mirror mechanism with negative energy topological light rays sent to the geometric past and inducing the neural activity as a response. Without this mechanism we could not survive using.3-.5 seconds old sensory data. A beautiful general scenario for the realization of intentions and unifying sensory perception, long term memories, and motor action emerges and allows to explain phenomena like sensory rivalry difficult to understand in neuroscience framework.

The flux tube structure associated with the Earth's magnetic field could define or at least closely relate sensory canvases of Mother Gaia and of smaller magnetospheric selves. It is quite conceivable that also magnetosphere contains various kinds of representations of the information from brain and body. The local direction of Earth's magnetic field at cortex should fix the orientation of the projectors associated with the sensory representations in the co-rotating inner magnetosphere. Pyramidal neurons contain magnetic crystals and also haemoglobin molecules are magnetic and their alignment with the local magnetic field of Earth would make this possible.

These representations could be responsible for the third person perspective which is also an integral part of our consciousness: the mechanism providing the third person aspect would be sharing of the mental images by quantum entanglement. Out-of-body experiences and near death experiences could be one particular manifestation for this component of consciousness. The magnetospheric representations could be also responsible for long term memory representations.

There are reasons to believe that also the non-rotating outer magnetosphere might contain representations. For these representations the projectors should be parallel to the flux tubes of a magnetic field which is stationary with respect to Earth. The flux tubes of the outer magnetosphere might be able to penetrate to some extent the inner magnetosphere and attach to brain or body. For instance, the magnetic field created by the magnetic particles in lungs is of the same magnitude as the magnetic field in the plasma sheet at the night side of Earth.

5.1.4   EEG as a Communication and Control Tool of Magnetic Body

The progress made during the year 2005 in the understanding of the dark matter hierarchy stimulated a quantum leap in many branches of TGD with the model of the magnetic body included. This forced some updating of also this chapter although I tried to not destroy the original flavor of the chapter. I also added a section about about a hierarchy of generalized EEGs associated with the dark matter hierarchy making possible for the magnetic bodies to receive sensory information from biological body and quantum control it. The chapter "The Hierarchy of Generalized EEGs and Dark Matter Hierarchy" [K44] provides a detailed vision about magnetic body as an intentional agent receiving sensory input from the biological body and using it as a motor instrument.

In this chapter a general vision about the magnetic sensory canvas hypothesis is discussed. The discussion continues in [K62]. These chapters are not a reviews of the final results after the dust has settled but document the development of ideas as it has occurred and is still occurring. There are many mammoth bones and little inconsistencies, and often the simple final picture is achieved by a lot of painful sidetracking. The very name "Magnetic sensory canvas hypothesis" of this chapter is a good example of this problem: both symbolic, cognitive and sensory mental images entangle with the magnetic body so that the attribute "sensory" is somewhat misleading. Furthermore, motor control aspect is equally important. Perhaps a better title would be "Magnetic body hypothesis". My sincere apologies for the reader for this: I can do only my best!

The appendix of the book gives a summary about basic concepts of TGD with illustrations. Pdf representation of same files serving as a kind of glossary can be found at `http://tgdtheory.fi/tgdglossary.pdf` [L18].

5.2   A model for aensory representations, long term memories, and motor actions

In this section a model of sensory representations will be developed from the assumptions that sensory representations are realized on magnetic body (magnetic sensory canvas) and that sensory organs are the seats of the sensory qualia. It turns out that the model is essentially equivalent with the model of long term memories and that its temporal mirror image yields a general model

for motor actions. The general vision is inspired by and explains Libet's strange findings about active and passive aspects of consciousness.

5.2.1 Magnetic Body As The Sensory Canvas

Many-sheeted space-time concept makes it possible to project the sensory, symbolic and cognitive mental images the external world using MEs and magnetic flux tube structures.

1. Place coding by cyclotron frequency scale could easily wake-up mental images representing the positions of the objects of the perceptive field in the magnetic body. A more attractive manner to see the situation is to identify magnetic body as an active perceiver sending negative energy topological light rays time reflected at the biological body as positive energy topological light rays and providing information about its state much like the ordinary reflection of light provides information about the object of the perceptive field.

2. The distance of the point of the flux tube from the sensory organ could be coded to the thickness of the flux tube which in turn defines the cyclotron frequency. Most naturally, the strength of the field is the strength of the corresponding Maxwellian magnetic field and the density of the magnetic flux tubes is scaled accordingly from the requirement of the quantization of magnetic flux.

3. The radial EEG MEs assigned with the cortical axons in the TGD based model of EEG could serve as projectors having contacts with the magnetic flux tubes of the personal magnetic body. MEs would entangle cortical mental images and sensory mental images at sensory organs with the "simple feeling of existence" mental images at the points of the magnetic body. Note that the magnetic bodies of sensory organs could carry the fundamental sensory representations.

4. The EEG frequency and its harmonics associated with ME would induce magnetic quantum phase transitions at the magnetic canvas and wake-up mental image at a distance corresponding to the estimated distance of the object of the perceptive field but which need not be same. The association of visual colors with the points of the perceptive field would result from the retina-magnetic body entanglement. Auditory experience might involve a similar mapping but might use Z^0 magnetic field as canvas. Also ears contain strong back-projections necessary for auditory dreams.

5. EEG MEs serving as projections to the magnetic canvas results in the cyclotron transitions at the magnetic flux tubes of endogenous magnetic field having strength $\simeq$ .2 Gauss (experiments of Blackman and others), which is 2/5 times the nominal value.5 Gauss for the Earth's magnetic field. At the magnetic flux tubes of the personal magnetic canvas similar process occurs. The rate for the transitions should be maximized in both cases. At the magnetic body this is achieved if the super-conduction ion at the magnetic flux tube is first "kicked" to a smaller space-time sheet wherefrom it "drops" back to the magnetic flux tube, and because of its zero point kinetic energy enters into a high n cyclotron state, which in turn decays by emitting harmonics of the cyclotron frequency. The "kicking" is achieved if the ELF ME responsible for the entanglement contain microwave MEs, which generate flux tubes connecting magnetic flux tube with smaller space-time sheets. This in turn leads to the breaking of super-conductivity and primitive metabolic cycle in which ions flow to the atomic space-time sheets and back to the magnetic flux tube. This would mean that the microwave radiation from brain serves as the "food" of the primitive plasmoid like life form representing the simple "feeling of existence" mental image at the magnetic sensory canvas.

   Both the quantum entanglement with the mediation of of ELF MEs giving rise to the fusion of mental images, and a classical communication by the transfer (say) microwave MEs and inducing self-organization at the magnetic body, are involved. This mechanism is the basic mechanism of remote mental interactions in TGD Universe.

6. An entire hierarchy of sensory representations are predicted and also primary sensory organs could have this kind of representations at their personal magnetic bodies. For instance, retinae could carry this kind of representations realized in the same manner as the cortical representations. These representations would entangle with cortical representations.

5.2.2   The Mental Images At The Personal Magnetic Body

The sizes of the images of the objects of the cortical sensory representation located outside the body would not correspond to the real size of the objects of the perceptive field. The sizes of ELF ME are typically of order Earth size and this gives upper bound for the size of the representative objects. If brain itself generates the magnetic canvas then it might be natural to expect that the scaling factor involved is one but one must be very cautious in making any strong conclusions. The problem are that it is not at all clear how this scaling factor could be achieved and how it could be useful. Furthermore, the requirement that the magnetic field strength along the flux tube varies very slowly supports the view that the sub-selves at magnetic body ("simple feeling of existence")can have sizes of order ELF ME.

The mapping of the apparent EEG wavelengths to ELF ME lengths $L = c/f$ defined by the formula $\lambda = v/f = (v/c)L$ for EEG frequency f in terms of its apparent wavelength $\lambda = v/f$ would is consistent with the idea that cortical objects could be scaled-up by a factor $c/v \sim 10^7$! Thus these mental images could be even of the order of the size of Earth! If so they could be extremely stable against external perturbations. In particular, the motion of the head and body would not affect the magnetic and Z^0 magnetic fields in this distance scale so that the problem of reference frame would be solved since "me" would be understood as a gigantic magnetic structure using brain and body as a sensory and motor organ. Obviously, this picture is the diametrical opposite provided by the standard neuroscience.

A more detailed model for the sensory representations requires a more comprehensive view about the personal magnetic body. One can make only tentative guesses in this respect.

1. The personal magnetic body interacts with the external world, in particular, with the Earth's magnetic field and with the solar wind carried by the solar magnetic field. Hence the idea about personal magnetic body as a structure analogous to the Earth's magnetosphere is worth of testing. Personal magnetosphere could decompose into a part moving with the physical body and analogous to the inner magnetosphere, and a stationary, highly stretched, part analogous to the outer magnetosphere at the night side of Earth. Also part residing outside the Earth's magnetosphere should be present. Earth's magnetosphere-solar magnetic field interaction would be replaced by personal magnetosphere-Earth's magnetosphere interaction.

2. Solar wind might enclose part of the personal magnetic body inside the Earth's magnetosphere, whereas the interaction with the flux tubes of the Earth's magnetic field could force the flux tubes of the personal magnetic body to be more or less parallel to them. Incoherent summation of the personal and terrestrial magnetic fields, fractality, plus the fact that the field strengths associated with the flux tubes of the personal magnetic body should decrease much slower with the distance from Earth's surface than those of the Earth's magnetic field, are consistent the possibility that the flux tubes of the personal magnetic body with field strengths stronger that of the Earth's magnetic field reside inside the magnetic flux tubes of the Earth's magnetic field in far-away regions. That part of the personal magnetic body which corresponds to field strengths weaker that the strength of the Earth's magnetic field could quite well have size measured in light years.

3. The highly self-organizing plasma sheet at the equitorial plane at the night side of the Earth's outer magnetosphere is an especially interesting structure as far as personal and magnetospheric sensory representations are considered. For the fractal option the plasma sheet of the Earth's magnetosphere would contain plasma sheets inside plasma sheets, in particular the plasma sheets associated with the personal magnetic bodies. Personal and magnetospheric sensory representations would correspond to different levels of the same fractal structure.

4. Also the intra-terrestrial part of the Earth's magnetosphere is important for the magnetospheric sensory representations and, if the fractality hypothesis holds true, also for the personal ones. The strange coincidences of important cavity resonance frequencies of intra-terrestrial structures with EEG resonance frequencies, and the fractal correspondence between the architectures of brain and magnetosphere [K62] support the view that personal magnetic body extends also to the interior of Earth. The flux tubes of the Earth's magnetic field (with field strength increasing faster than for the flux tubes of the personal magnetic body) would be however contained *inside* those of the personal magnetic body in this region.

The intra-terrestrial consciousness would therefore represent sub-...-selves of ours, something analogous to Id whereas magnetospheric sensory representations would correspond to the super ego. This interpretation conforms with the proposal that intra-terrestrial life forms are possible in the many-sheeted space-time, and that crop circle formations could be interpreted as attempts of ITs to communicate about their existence [K41, K42].

5. Probably it makes sense to speak about Z^0 magnetosphere (both solar and terrestrial). Z^0 magnetic flux tube structures are crucial for the model of long term memories [K96], and the sizes of the flux tube structures associated with the personal Z^0 magnetic body should be measured in light years. This suggests that also much weaker personal magnetic and Z^0 magnetic fields with the lengths of the closed flux tubes measured in light years are relevant.

5.2.3 Cortex As A Collection Of Attributes Assigned To The Objects Of Perceptive Field Represented At Magnetic Canvas

One of the basic problems related to the understanding of the information processing in brain is how various attributes are assigned to the object of the perceptive field. What is known that brain recognizes features and these features/attributes seem to be located in a more or less random looking manner all around cortex. This brings strongly in mind random access memory or computer game in which various little program modules realized as records in random access memory represent collection of standard sound effects. A strong hint is the empirical evidence for the view that the resonance frequencies associated with the autocorrelation functions of nerve pulse patterns, and thus presumably also coding EEG frequencies, are same for the features associated with a given object of the perceptive field. The challenge is to understand how the picture based on a collection of MEs projecting features to the magnetic canvas could allow to understand what is behind these observations.

The view about MEs associating attributes to the object of the perceptive field by waking up sub-selves in the magnetic flux tube structure serving as a sensory canvas suggests an elegant interpretation for these facts.

1. Brain writes the music played by the sensory organs to notes. Accordingly, cortex can be regarded as a collection of regions specialized to represent various kinds of standard features interpreted as cognitive and symbolic representations for the sensory input whereas sensory qualia are realized at the level of sensory organs. Features need not be simple: arbitrary complicated collections of them, such as symbolic representations familiar faces are also possible features. Even entire dynamical processes (selves) could serve as features. Cortical mental images entangled also with sensory mental images a the level of sensory organs and at various organs. The pain in the heart is really in the heart.

2. Basic feature-regions are like computer records. The information about the position of the feature in perceptive field could be represented by the entanglement of the feature with a particular part of, say, primary sensory area representing a point of the perceptive sphere.

3. The direction of the point of the perceptive field could be coded basically by the direction of the magnetic flux tube emerging from the particular position of the sensory area providing map for solid angles of the perceptive field. The mechanism would be based on resonance with Alfven waves associated with the magnetic flux tubes of personal magnetic body amplifying MEs in the direction of magnetic flux tubes. The length (fundamental frequency) of ME would code for the distance of the point of the perceptive field to the distance of the point of the sensory magnetic canvas. Frequency coding could be achieved by varying the local value of the magnetic field responsible for generating the cyclotron frequency. This coding could be either dynamical or static in which case distance could be most naturally coded to linear structures, most naturally in direction orthogonal to the cortical surface.

4. Features would be basically associated with sensory organs, various neural pathways and brain areas and coded partially by nerve pulse patterns. Features could be practically all kinds of sub-selves generated by brain activity. Primary qualia could be realized at the level of sensory receptors if entire sensory pathways entangle with the magnetic body. It seems

that the identification of sensory organs as seats of sensory qualia is the most, and perhaps the only, plausible option in TGD framework.

5. Projector MEs would be orthogonal to the sensory area where they emanate. The topographic mapping of the perceptive field to the sensory areas would guarantee that sensory images would remain stationary under rotations of head: although sensory magnetic sensory canvas would move the image projected to it would be stationary. MEs and magnetic flux tubes must be parallel if Alfven wave resonance is involved. In this manner the experiences could remain private and the contribution from the other brains would remain negligible. Note however that people in very intimate contact could gradually share there magnetic sensory canvases: the anecdotes about gradually developing telepathic communications between the teachers and students of the meditative practices could involve this kind of sharing of computer screen between several users.

6. In this coding EEG MES would entangle with essentially all symbolic information about the perceptive field and the spectroscopy of consciousness would be realized in a strong sense.

Of course, the extreme flexibility of the entanglement mechanism of binding means that one can imagine almost unlimited number of variants about this basic option and the proposed variant can be defended only as the simplest one found hitherto. One can also allow the possibility that the sequence of entanglements begins from the perceptive field with the primary mental images at the level of sensory organs being entangled with objects of perceptive field.

Fractality suggests that there is a hierarchy of representations. In particular, cortex areas, brain nuclei and even cells could possess their own representations. The inactivity of the primary sensory areas during REM sleep could mean that during dream state sensory representations are non-cortical lower level representations or realized at higher sensory areas. Of course, lower level structures could define the projections to the magnetic sensory canvas also during wake-up consciousness. For instance, relay station like nuclei could act as relay stations for the projections realized at the magnetic body. Any brain area defining topographical map of sensory data is could candidate for defining a sensory representation.

The projector regions could serve as kind of central entanglers. Also the nuclei believed to somehow generate EEG resonance frequencies responsible for the binding of mental images are good candidates for the central entanglers. Thalamus is believed to generate 40 Hz rhythm and is thus a good candidate for the central sensory entangler and projector. Hippocampus generates hippocampal theta and could be the central memory entangler and projector. Frontal lobes generate slow EEG waves during cognitive activities and could act as cognitive entanglers and projectors.

This kind of architecture is expected to be realized at various length scales. Perhaps even at the length scale of genes. The remaining question is how motor activities are realized in this picture. The metaphor for consciousness as a computer sitting at its own terminal, which originally stimulated my personal attempts to understand consciousness, might help here. Computer screen corresponds to the magnetic canvas. The one who sits there presumably corresponds to our magnetic body (as far as conscious-to-us intentions are considered). The central unit corresponds to the brain. Sensory projector MEs are generated automatically by nerve pulse activity and code the picture on the monitor. W MEs as active quantum holograms acting as control commands generating nerve pulse patterns would provide a realization of keyboard. Thus it would seem that those aspects of the computer which are usually not regarded as fundamental in Turing machine paradigm are the most crucial for understanding the brain consciousness and computer programmers seem to mimic what happens inside (and outside) their own brain.

5.2.4 Place Coding

If the personal magnetic body corresponds to the sensory experiencer and the intentional agent, the distance from the brain along the magnetic flux tube represents the temporal distance to the geometric past. It is however quite possible and even plausible that the length of the magnetic flux tube can code for some spatial distance and even more general geometric data. The arrow of the geometric time would order the spatial points. This kind of mapping from the spatial domain to the temporal domain to the personal magnetic body is naturally induced by any scanning like process performed by CNS, say saccadic motion or EEG waves propagating along cortex. Thus it makes

sense to speak about place coding even if one does not assume that our body and environment are mapped to the personal magnetic body in a topographical manner.

The required place coding by frequency is easy to achieve. Any cylindrical flux tube for which magnetic field in the cylindrical coordinates is obtained from a vector potential $A_\phi(z, \rho, \phi) = B(z)\rho$ varying slowly with z gives rise to a magnetic field whose z-component varies slowly with z and for which the radial component $B_{rho} = \partial_z B(z)\rho$ is small. From the quantization of the magnetic flux the flux tube thickness behaves as

$$\frac{r}{r_0} \propto \frac{B_{earth}}{\sqrt{B(z)}} \quad ,$$

and flux tube gets thinner if the field strength increases and vice versa. It the strength of the magnetic field is that of Earth's magnetic field at the surface of the retina or secondary sensory organ, one obtains frequency coding

$$\frac{f}{f_{earth}} = \frac{B(z)}{B_{earth}} \quad .$$

This means that a given EEG frequency associated with, say color mental image, induces a magnetic quantum phase transition at a definite value of z and wakes up visual sub-self at that position. The resulting experience is colored point at a specific point of the visual field.

Optimal situation is achieved if the gradient of B with respect to z is very small. This would suggest that self sizes are of order of the size of ELF MEs waking-up the mental images. This would mean that the total increment of $B(z)$ along flux tube would be measured using B_{earth} as a natural unit. p-Adic length scale hypothesis suggests that the thickness of the magnetic flux tube varies between two p-adic length scales and thus by a small power of 2.

It deserves to be noticed that a given EEG frequency f can wake up a number of copies of sensory images corresponding to various ions at positions related to each other by

$$\frac{B(z_1)}{B(z_2)} = \frac{A_1 Z_2}{A_2 Z_1} \quad .$$

Here A_i and Z_i denote the mass numbers and charges of the ions, results. If $B(z)$ varies very slowly along the flux tube, the number of separate mental images is however small since the condition above cannot be satisfied for too large ratios on the right hand side. If $B(z)$ increases along the flux tube, the images associated with the light ions are nearer to the eye than those associated with the heavy ions.

This observation suggests that ions with nearly the same mass numbers could give rise to multiple sensory representations associated perhaps with same sensory sub-self. Of course, the degeneracy of the mental images might be undesirable and could be eliminated by adjusting the gradient of B to be so small that multiple sensory images are not generated inside given magnetic self. By a small adjusting of the strength of the magnetic field at eyeball or the radius of the secondary visual sensory organ could shifts between various types of ionic visual consciousness could be induced. For heavy ions, isotopic degeneracy would lead to large number of alternative modes of ionic consciousness and this might give rise to enhanced cognitive abilities.

How faithful is the metric correspondence between the visual field and its image at the magnetic body? The answer is to this question is not obvious. Also eyes are accompanied by magnetic bodies which could carry visual representations and primary sensory qualia. It could be that these representation are responsible for all what relates to the experienced metric aspects of the visual field. If this is the case, the representations at the personal magnetic body could be much more abstract and free from the constraint of the isometric correspondence. The hierarchy of sensory areas in brain indeed corresponds to an increasingly higher level of abstraction.

5.2.5 Magnetospheric Sensory Representations

It is difficult to exclude magnetospheric sensory representations if one accepts the notion of personal magnetic body and representations at it. These representations could give rise to the third person aspect of consciousness. Magnetosphere could contain multi-brained collective selves receiving sensory input from several brains simultaneously. Also Z^0 magnetosphere could contain

representations carrying both sensory and and higher level symbolic and cognitive information from several brains.

The location of the magnetospheric representations could be stationary with respect to the inner magnetosphere. This would require that the MEs projecting the information to the magnetosphere emanate from the head in a direction which is fixed with respect to the local direction of the magnetic field of Earth (the MEs associated with the personal magnetic body would project in a direction orthogonal to the surface of cortex). Most naturally this direction would be the direction of the local magnetic field since this makes possible amplification based on Alfven wave resonance. Stationarity of the directions of MEs projecting to the magnetosphere could be achieved by the interaction of the magnetic dipoles with Earth's magnetic field forcing the directions of the magnetic dipoles to the direction of Earth's magnetic field and thus making brain a compass. Brain is indeed full of magnetic materials, human brain is a compass and humans have magnetic navigation sense.

Also eyes contain magnetic materials and presumably act as compasses so that eyes could generate the required magnetic fields defining a preferred reference frame for visual sub-selves. One can consider a hierarchy of compasses defined by the hierarchy of magnetic fields at various sheets of the many-sheeted space-time. For the sense of balance this kind of a preferred direction is essential.

Also a Z^0 magnetic compass based on Earth's magnetic field and Z^0 magnetic materials is possible. The fact that Z^0 magnetic fields are associated with hearing so closely in TGD framework supports the view that Z^0 magnetic compass could be related to the sense of balance. Children love to spin around. Since all atomic nuclei couple to Z^0 force, this spinning however generates net Z^0 currents generating additional Z^0 magnetic fields perturbing the Earth's Z^0 magnetic field. This in turn could cheat the Z^0 compass. This indeed happens. When the spinning stops, sensation of dizziness results and the world is experienced to spin.

5.2.6   Remote Mental Interactions And Sensory Magnetic Canvas Hypothesis

Could the possible sensory inputs from other brains to the personal magnetic body interfere with the sensory inputs from "my brain" ? This is probably not the case. It is however possible that the entanglement with the other magnetic bodies and possibly existing magnetospheric multi-brained selves leads to the sharing of mental images. Perhaps this is exactly what happens during sleep and actually makes possible development of social structures and culture. Note that this picture is consistent with what near death experiences and various altered states of consciousness achieved in meditative practices suggest.

There is some evidence for the possibility of a interaction between minds via projected sensory representations. Some dogs are able to anticipate the epileptic attacks of their master and are systematically trained for this purpose. Some dogs have an amazing skill to precognize that their master is coming home: ordinary sensory perception such as olfaction is excluded as an explanation. The practitioners of transcendental meditation claim that collective meditation can have a definite positive effect on conflict situations occurring at the other side of the world proportional to the square of the number of participants (coherence). The vision of Sheldrake [L9] about morphogenetic fields making possible the claimed learning at the level of species could be modelled concretely in terms of this interaction.

The immediate prediction is that large scale phenomena affecting the magnetic field of Earth should have direct effects on our consciousness by the perturbation of the sensory representations at the other side of the world. There would be however no effect on primary sensory qualia if they are seated at the level of sensory organs nor on cognitive and symbolic mental images produced in brain. Telepathic sharing of mental images having would be one possible effect induced by Schumann resonances: the signature would be sensory experience with no neurophysiological correlates (in particular, there would be no back projection to sensory organs).

It is known that the statistics about mental states of patients of mental hospitals demonstrates strong correlation with magnetic storms induced by sun-spots. The magnetic perturbations induced by lightnings known as sferics are known to have a direct effect on EEG and brain functioning [F2]. Tectonic activity, such as Earth quakes, can induce various kinds of hallucinations such as encounters with UFOs and religious experiences [J103] perhaps involving sharing of mental

images. Animals are even able to anticipate earth quakes. When the car ferry Estonia suffered a shipwreck for few years ago taking with it almost thousand people into the depths, hundreds of people reported they had experienced a nightmare obviously relating to this event. Sharing of mental images or sensory percepts produced by back-projection from symbolic representations created by or communicated to brain could be in question.

The known general features of remote mental interactions support the view that magneto-spheric multi-brained selves serve as a kind of relay station or medium allowing the remote mental viewer to entangle with the target. Remote viewer would essentially see with the yes of this higher level self [K93, K23].

5.2.7 Mirror Mechanism Of Geometric Memories

The mirror mechanism of long term memories involves several purely TGD based features [K96].

1. The classical non-determinism making possible time-like quantum entanglement and sharing of mental images.

2. Space-time sheets with a negative time orientation allowing classical signals associated with negative energy MEs to propagate backwards in time and making possible entanglement.

3. The identification of the personal magnetic body as the experiencing intentional agent sending negative energy MEs parallel to the magnetic flux tubes to the brain acting as the time mirror (see **Fig. http://tgdtheory.fi/appfigures/timemirror.jpg** or **Fig. ??** in the appendix of this book). This option, forcing to take completely seriously the notion of the magnetic body, provides the most elegant identification of the time mirror discovered hitherto. If brain is identified as the sender of the negative energy MEs, the identification of the mirror and correct timing of pose problems. One possibility is that the closed flux loops associated with the personal magnetic and Z^0 magnetic bodies having sizes of order light years making it possible for negative energy MEs to repeatedly reflect along them and return back to the brain of the geometric past.

4. The possibility of MEs and magnetic flux tubes interacting weakly with the ordinary matter but strongly with living matter in cell length scales.

Time mirror mechanism

Classically the mechanism of long term memory is extremely simple: one looks at time mirror at a distance of one light year and sees oneself in the geometric past at a distance of two years. Since the geometric past changes in each quantum jump, this mechanism explains why our long term memories are so unstable. One could see also other persons in the mirror and this could explain telepathic communications, the communications with the deceased, as well as identification experiences. The most natural identification of the seer is as the magnetic body and the mirror as the brain (my first guess was time mirror image of this!). The distance along the magnetic flux tube would corresponds to the distance to the geometric past.

For the time-mirror model (see **Fig. http://tgdtheory.fi/appfigures/timemirror.jpg** or **Fig. ??** in the appendix of this book) of long term memory recall the ULF dark MEs must be generated both at the personal magnetic body and in the brain.

1. At the personal magnetic body cyclotron phase transition would give rise to negative energy neutral MEs sucking energy from the biological body of the geometric past. This radiation would be reflected back to the geometric future as positive energy neutral MEs. The response would depend on the state of the brain. Motor action would differ from memory recall only in that it would involve negative energy W MEs inducing exotic ionization at both ends and leading to a physiological outcome. The entanglement via W MEs could induce direct sensory memories relying on sharing and fusion of mental images.

2. The ULF radiation representing the response to the memory recall would correspond to Josephson radiation giving rise to a scaled up dark EEG in the relevant time scale characterized by the level of the dark matter hierarchy. The de-coherence of higher level dark photons

to single ordinary EEG dark photon or their decay to EEG dark photons is probably involved with the memory call and would transform the response from the geometric past to ordinary cognitive and emotional input at personal magnetic body.

The assumption that the lengths scales of MEs and magnetic structures are identical implies that the frequency of ME equal to the magnetic transition frequency f_m fixes the length of the two MEs involved and thus the temporal location of the long term memory in the geometric past:

$$T = \frac{2}{f_m} \quad .$$

This represents a frequency coding for the temporal location. In standard physics the idea about brain generating MEs with a frequency scale of the order of the inverse of lifetime does not make sense: in TGD context situation is different since this process occurs in subjective time. By the arguments discussed in more detail below, positive energy neutral MEs are ideal for communication of long term memories to the geometric future. The concrete mechanism for the generation of MEs as associated with transitions between almost degenerate configurations of spin glass with slightly different classical gravitational energies is discussed in [K96].

More detailed model for long term memories

The realization of long term memories might be the basic function of the personal magnetic body.

1. Spontaneous episodal memories would be based on negative energy MEs entangling the geometric now with the geometric past and making possible sharing of mental images. In particular, sensory memories would rely on this mechanism. This mechanism could also make possible only the communication of the desire to remember to the geometric past in the case of an active memory recall and non-episodal memories. One can however wonder what distinguishes the resulting experience from precognition by the self of the geometric past: could it be that to precognize now is to remember in the geometric future? The fact that MEs represent channelled energy means that distance is not a problem as far as energetics is considered.

2. In the case of non-episodal memories the information could be communicated classically from the geometric past as "bits" and be coded into the light like vacuum current associated with ME. If the magnetic body is the "me", positive energy MEs could simply travel along the same magnetic flux tube along which the negative energy ME arrived. Magnetic flux tube would act as a wave guide amplifying ME by Alfven resonance.

3. Neural MEs with negative energies are especially favored for quantum communications. The reasons are many-fold. The interaction with the matter is very weak in long length scales but strong in cellular length scales, negative energy implies that ME is identifiable as a virtual particle and analogous to a part of a Feynman diagram so that no dissipation is involved and quantum communication is possible. The reversal of the arrow of geometric time means also that there is not macroscopic dissipative dynamics which would spoil the quantum coherence.

4. The requirement that the receival process is highly selective suggests a resonance mechanism. This requires that the fundamental frequencies associated with MEs are somehow universal. p-Adic length scale hypothesis indeed predicts hierarchies of universal frequencies. A stronger requirement is that the receiving and sending structures are somehow similar, and many-sheeted space-time allows to realize this kind of option. Negative energy energy ME cannot be emitted unless there is a receiver absorbing the negative energy and in this manner providing energy for the sender by buy now-let others pay mechanism. The time mirrored positive energy ME can even amplify the reflected negative energy signal by stimulated transition to the ground state if the receiver is a many-sheeted analog of a population inverted laser.

5. Negative energy MEs represent time reversed level of the p-adic length scale hierarchy so that the dissipative effects associated with the space-time sheets with the normal arrow of time should not interfere with the quantum communication. This at least, when the energy of the negative energy ME has a magnitude larger than the thermal energy associated with

the space-time sheets with which it interacts: there is simply no system which could make a transition to a lower energy state by the absorption of a negative energy ME. Furthermore, since systems with reversed arrow of geometric time are expected to have extremely low density, the dissipative effects in the reversed direction of time are expected to be small. Since the generation of negative energy MEs does not require energy feed, the memory recall to the geometric past occurs more or less spontaneously, and the scanning of the geometric past becomes possible. In the case of precognition precognizer must intentionally receive negative energy MEs from the geometric future so that energy feed is needed. This perhaps explains why precognition is so rare. Note that p-adic variant of pre-cognition having interpretation as intentionality occurs easily since p-adic energy is conserved only in piecewise manner.

If this picture has captured something essential from the nature of the long term memories, the conclusion is that we are not at the top of the magnetic sensory hierarchy. Human body and brain generates extremely weak magnetic fields and the corresponding magnetic flux tube structures could make possible long term memories. Near death experiences [K27] could be understood in this framework if the weak magnetic fields associated with the higher levels of the fractal hierarchy of magnetic structures utilize brain and body as kind of sensory and motor organs. Note that there is a flux tubes inside flux tubes structure so that ordinary sensory experiences can be associated also with these flux tubes.

5.2.8 Sensory Perception, Motor Action, And Time

TGD view about sensory perception differs dramatically from that of the standard neuroscience in that sensory organs (plus possibly their magnetic bodies) are carriers of basic sensory representations and the magnetic body rather than body or brain is the experiencer with which we can identify ourselves. Magnetic body is also the intentional agent and both motor action, sensory perception, and long term memory which all involve also intentional elements, are based on the time mirror mechanism. Intentions are represented by p-adic MEs generated at the magnetic body. p-Adic ME is then transformed to a desire about a particular action and represented as a negative energy ME propagating to the direction of the geometric past. Actions are realized as responses to the negative energy MEs as various kinds of neural activities and as a generation of positive energy MEs. A more realistic model involves an entire sequence of this kind of steps proceeding like a sequence of sub-program calls downwards along the hierarchy of the magnetic bodies down to the level of CNS. A good metaphor is obtained by regarding magnetic bodies as bosses in the hierarchy of some organization and CNS as the lowest level ultimately realizing the desire of the big boss.

Sensory organs as seats of qualia

According to the music metaphor, sensory organs are responsible for the music whereas brain writes it into notes by building symbolic and cognitive representations communicated to the magnetic body. Back projection to the sensory organs is an essential aspect of this process and is discussed in [K50]. Sensory perception at the level of magnetic body involves the generation of negative energy MEs entangling with sensory organs involving possibly also brain as an intermediate entangler.

The assumption that sensory organs are carriers of the sensory representations entangling with symbolic representations realized at the level of cortex does not mean any revolution of neuroscience, just adding something what is perhaps lacking [K50]. One can also consider the possibility that sensory organs and their magnetic bodies define the sensory capacitors whose discharges give rise to sensory qualia and that these magnetic bodies give also rise to low level cognitive and emotional representations.

Neuronal/symbolic level would do its best to symbolically represent what occurs naturally at the level of qualia. Color constancy could be understood as a basic characteristic of color qualia represented symbolically at the neuronal level. Center-surround opponency for the conjugate colors is the neural counterpart for the contrast phenomenon in which the boundary for a region of the perceptive field with a given color carries the conjugate color (black-white opponency associated with the luminance is only a special case of this). The contrast phenomenon at the level of visual qualia could derive from the vanishing of the net color quantum numbers for the electrodes of the retinal color capacitors.

The basic prediction is the presence of the back projection at least in the sensory modalities in which hallucinations are possible. MEs with MEs mechanism is the most natural candidate for realizing the back projection, negative/positive energy MEs would realize the back projection based on quantum/classical communications, and the capacitor model of the sensory receptor can be applied to model photoreceptors and retina. This picture integrates nicely with the various speculations about the role of the ciliary micro-tubules in vision. The obvious question is how the presence and character of the back projection reflects itself in the structure of the sensory pathways and sensory organs.

Basic facts about how gastrulation and neurulation proceed during the development of the embryo, lead to testable hypothesis about the character of the back projection for various sensory modalities. According to the hypothesis, one can speak about "brain senses" and "skin senses" according to whether the back projection is based on quantum or classical communications.

How motor action differs from sensory perception?

There is a deep similarity between sensory perception and motor action in TGD framework, the basic difference being that classical signals propagate in different direction in CNS and in geometric time. Motor action is initiated by the magnetic body by the sending of negative energy to motor organs by generating negative energy MEs, and proceeds by similar processes backwards in the geometric time to the level of brain and magnetic body, very much like an instruction of a boss at the top of organization to the lower levels of hierarchy and induces lower level instructions. The analogy with computer program calls (quantum communications, desires) and their executions (classical signals, actions) is also obvious. Also classical signals from the magnetic body to the body and brain are possible.

Analogous picture applies to sensory perception with motor organs replaced by sensory organs except that the fundamental communications occur to geometric future from biological body to magnetic body via a hierarchy of EEGs. There is however also an active building of sensory percepts by feedback from the magnetic body which selects between quantum superposed alternative percepts already at the level of sensory organs.

Sensory *resp.* motor imagination differ from sensory perception *resp.* motor action only in that the magnetic body entangles with some higher level of CNS. Therefore there is no danger that imagined motor action would become real or that imagined sensory perception would be experienced as real. This picture is in accordance with the idea of quantum credit card implying maximal flexibility, and with respect to the geometric time would mean that motor actions are only apparently initiated from the brain.

Strange time delays of consciousness: experiments related to the active role of consciousness

Libet has carried out classical experiments about active and passive aspects of consciousness [J52, J22]. It has gradually become clear that these experiments can be interpreted as a support for the identification of "me" as the personal magnetic body. The first class of experiments [J115, J22] is related to the active role of consciousness. For example, the human subject moves his hand at free will. What happens is that neurophysiological processes (changes in EEG, readiness potential) start $T_1 = .35 - .45$ seconds before the conscious decision to move the hand whereas the awareness about the decision to move the hand comes $T_2 = .2 - .1$ seconds before the hand movement. Decision seems to be followed by the action rather than action by decision! This is in apparent accordance with the point of view that consciousness is indeed a passive spectator and the act of free will is pure illusion. What is interesting from the p-adic point of view, is that the most plausible estimates for the time delays involved are $T_1 \simeq .45$ seconds and $T_2 = .1$ seconds [J115]. T_1 is very near to the p-adic time scale $T(6, 43) = .4$ seconds and T_2 to the fundamental p-adic time scale $T(2, 127)$ defining the duration of the memetic codon.

One can imagine two explanations for the paradoxal findings. The explanations turn out to be mutually consistent.

1. The geometric past changes in quantum jump

Quantum jump between histories picture explains the time delays associated with the active aspect of consciousness nicely and also gives an example of two kinds of causalities.

1. The simplest assumption is that the subjective experience of the hand movement corresponds to the moment, when subject person experiences that hand movement occurs.

2. The space-time surfaces (resulting as the final state of quantum jump) associated with the new quantum history differ in a detectable manner from the old quantum history already before the moment of hand movement since otherwise the new space-time surface would contain an instantaneous and discontinuous jump from the initial to final body configuration, which is not allowed by field equations. Same argument applies to the state of brain. $\Delta T \sim .5$ seconds seems to be the relevant time scale.

3. The attempt of the experimenter to be objective means that in an ideal experiment the observations correspond to the new deterministic history in the associated quantum jump and hence experimenter sees neurophysiological processes as the (apparent) cause of the hand movement with respect to geometric time. With respect to the subjective time the cause of the hand movement is the decision of the subject person.

2. Motor action is initiated from the magnetic body and proceeds to shorter length scales in reversed direction of geometric time

The vision that motor actions are initiated by magnetic body by feeding negative energy to motor organs and proceed upwards in CNS in a reversed time direction is in accordance with the idea of quantum credit card implying maximal flexibility and would mean that motor actions are only apparently initiated from brain. Motor organs send negative energy MEs to get metabolic energy, say to cortex. If there is lapse $\sim .5$ seconds involved then the observed lapse would find explanation. This view concretizes the idea about the editing of the geometric past and is consistent with the more general explanation discussed above.

This view about motor action means that it proceeds from long length scales to short ones whereas in the standard neuroscience view motor motor action would be planned and initiated in the brain and proceed to the level of motor organs, from short to long length scales. This certainly seems to be the case if one looks only the classical communications (say nerve pulse patterns). The extreme coherence of and synchrony of motor activities is however in conflict with this picture: neuronal communications are simply too slow to achieve the synchrony. This has been emphasized by Mae-Wan Ho [I121]. Since quantum communications proceed backwards in geometric time, classical signalling such as nerve pulses from brain to motor organs are actually reactions to the initiation of the motor action from the magnetic body.

Strange time delays of consciousness: experiments related to the passive role of consciousness

Libet's experiments [J52] about the strange time delays related to the passive aspects of consciousness have served as a continual source of inspiration and headache. Every time I read again about these experiments, I feel equally confused and must start explanations from scratch.

What is so important and puzzling is that the backwards time referral of sensory experience is so immensely long: about.5 seconds. The time taken for nerve pulses to travel through brain is not more than .01 seconds and the time to arrive from sensory organs is at most.1 seconds (for axon with length of 1 meter and very slow conduction velocity 10 m/s). For the purposes of survival it would be advantageous to have a sensory input with a minimal time delay.

Why then this long delay? TGD inspired answer is simple: the "me" does not correspond to the material body but to the magnetic body associated with the physical body, and is analogous to the manual of electronic instrument, kind of a monitor screen to which sensory, symbolic and cognitive representations are projected by quantum and classical communications. Since the size of the magnetic body is measured using Earth's circumference as a natural unit, the long time lapse results from the finite velocity of light.

The following explanation is a variant of the model of the sensory representations on the magnetic canvas outside the body and having size measured by typical EEG wave lengths. The

basic sensory representations are realized at the level of the sensory organs and entangled with magnetic body whereas symbolic representations are either shared as mental images by or communicated classically to the magnetic body. This differs from the original scenario in which sensory representations were assumed to result by classical communications from brain to the magnetic body.

1. Communications from brain to magnetic body

One must consider two kinds of communications from body to magnetic body corresponding to positive energy MEs generated by at least brain and negative energy ME sent by magnetic body to at least sensory organs. The assumptions are following.

1. Negative energy MEs bound state entangle the magnetic body with the sensory representations realized at the level of sensory organs, and constructed using back projection from brain and possibly also from higher levels. Fusion and sharing sensory mental images is involved. Also the classical communication of memories to magnetic body could be involved with the build up of sensory and symbolic representations at the magnetic body. In both cases sensory representations are memories with the same time lapse determined by the length of the MEs involved, a fraction of second typically if the magnetic body is of an astrophysical size. During sensory and motor imagination magnetic body entangles by negative energy MEs with some higher level of CNS.

2. Symbolic representations in brain can entangle with the sensory representations entangling in turn with the magnetic body so that CNS defines tree like structure with roots corresponding to sensory organs and branches and leaves corresponding to the higher levels of CNS. Direction of attention selects some path along this tree somewhat analogous to the path defining computer file in some subdirectory.

3. Symbolic representations of the perceptive field can be projected to the magnetic body using also classical signalling by positive energy MEs with phase velocity in a good approximation equal to the light velocity. For instance, if perceptive field contains something important, classical signal to the magnetic body could induce the generation of negative energy MEs turning attention to a particular part of perceptive field. Projection to the magnetic flux tubes of the Earth's magnetic field is possible. The spatial direction of the object could be coded by the direction of ME located in brain whereas its distance could be coded by the dominating frequency of ME which corresponds to a magnetic transition frequency which varies along the radial magnetic flux tubes slowly so that place coding by magnetic frequency results. Field pattern could be realized the coding of information to bits in some time scale, perhaps even in the time scale of millisecond associated with the memetic code. Positive energy MEs generated by brain realize the representation and this implies time delay. In the original model it was assumed that the direction and distance of the object of perceptive field are coded as direction and distance at the magnetic body. The representations are expected to be rather abstract, and it might be enough to perform this coding at the level of magnetic bodies associated with the sensory organs.

2. Libet's findings

Libet's experiments [J52] about the strange time delays related to the passive aspects of consciousness serve as a continual source of inspiration and headache. Every time one reads again about these experiments, one feels equally confused and must start explanations from scratch. The following explanation is based on the model of the sensory representations on the magnetic canvas outside the body and having size measured by typical EEG wave lengths [K94].

The basic argument leading to this model is the observation that although our brain changes its position and orientation, the mental image of the external world is not experienced to move: as if we were looking some kind of sensory canvas inside cortex from outside so that the motion of canvas does not matter. Or equivalently: the ultimate sensory representation is outside brain at a fixed sensory canvas. In this model the objects of the perceptive field are represented on the magnetic canvas. The direction of the object is coded by the direction of ME located on brain whereas its distance is coded by the dominating frequency of ME which corresponds to a magnetic

transition frequency which varies along the radial magnetic flux tubes slowly so that place coding by magnetic frequency results.

According to the summary of Penrose in his book "Emperor's New Mind" these experiments tell the following.

1. With respect to the psychological time of the external observer subject person becomes conscious about the electric stimulation of skin in about .5 seconds. This leaves a considerable amount of time for the construction of the sensory representations.

2. What is important is that subject person feels no time delay. For instance she can tell the time clock shows when the stimulus starts. This can be understood if the sensory representation which is basically a geometric memory takes care that the clock of the memory shows correct time: this requires backwards referral of about .5 seconds. Visual and tactile sensory inputs enter into cortex essentially simultaneously so that this is possible. The projection to the magnetic canvas and the generation of the magnetic quantum phase transition might quite well explain the time lapse of .5 seconds.

3. One can combine an electric stimulation of skin with the stimulation of the cortex. The electric stimulation of the cortex requires a duration longer than .5 seconds to become conscious. This suggests that the cortical mental image (sub-self) is created only after this critical period of stimulation. A possible explanation is that the stimulation generates quantum phase transition "waking up" the mental image so that threshold is involved.

4. If the stimulation of the cortex begins (with respect to the psychological time of the observer) for not more than .5 seconds *before* the stimulation of the skin starts, both the stimulation of the skin and cortex are experienced separately but their time ordering is experienced as being reversed!

   A crucial question is whether the ordering is changed with respect to the subjective or geometric time of the subject person. If the ordering is with respect to the subjective time of the subject person, as it seems, the situation becomes puzzling. The only possibility seems to be that the cortical stimulus generates a sensory mental image about touch only after it has lasted for .5 seconds.

   In TGD framework sensory qualia are at the level of of sensory organs so that the sensation of touch assignable to cortical stimulation requires back-projection from cortex to the skin. The mental images generated by direct stimulation of cortex could be called cognitive this is created first and takes some time. If the construction of cognitive mental images about cortical stimulation and the formation of back projection takes at least about.5 seconds the observations can be understood. Genuine sensory stimulus starts to build cortical mental image almost immediately: this mental image is then communicated to magnetic body.

   For instance, assume that the preparation of cognitive mental image at cortex takes something like.4 seconds and its communication to magnetic body about.1 seconds and that back projection is possible only after that and takes roughly the same time to the sensory organs at skin and back. This would explain the change of time order of mental images.

5. If the stimulation of the cortex begins in the interval $T \in [.25 - .5]$ seconds *after* the stimulation of the skin, the latter is not consciously perceived. This effect - known as backward masking - looks really mysterious. It would be interesting to know whether also in this case there is a lapse of.5 seconds before the cortical stimulation is felt.

   If the construction of cognitive mental image about direct stimulation of cortex takes about.4 second, it does not allow the buildup of cognitive mental image associated with the stimulation of skin. Hence the stimulation of skin does not create conscious cognitive or sensory mental image communicated to magnetic body.

5.3 First attempts to telate sensory sanvas idea to neuro-science

The challenge to relate sensory canvas hypothesis to the general qualitative features of EEG and to what is known about its evolution. The general knowledge about neural correlates of consciousness could also provide constraints for the model of how sensory representations are constructed. One could also try to find clear tests and even existing evidence for the hypothesis that there indeed are also other than neural correlates of consciousness (MEs projecting to the sensory canvas are obviously the candidate in present case).

There seems to be a general consistency of predictions of sensory canvas hypothesis with what is known about EEG. Mention only the evolution of EEG as the emergence of decreasing EEG frequency scales; the disappearance of alpha, beta and gamma bands from EEG during sleep; the existence of narrow coherent EEG sub-bands in all EEG bands; and also the complex fractal like coherency structures of EEG difficult to understand if EEG has a purely neural origin.

Brain is active also during sleep. Sensory canvas hypothesis encourages to think that, besides making possible consolidation of long term memories, this activity could serve the purposes of higher level multi-brained magnetic selves representing collective levels of consciousness receiving abstract non-sensory input from several brains at theta and delta frequencies. Of course, interaction could occur also in reverse direction and among other things explain the creative insights often achieved during sleep.

Computer metaphor would suggest that motor actions and sensory representations are basically identical procedures in TGD framework: only the final representation of the data file constructed by brain is different. As found, this is not quite the case: there is time reversal involved. Motor action is like precognitive recall whereas sensory experience is like geometric memory recall.

The considerations below rely on various review articles [E3], [J111, J39] about the recent situation concerning the understanding of EEG. Also the article [J74] about neural correlates of consciousness, and the article [J88] suggesting that primary sensory area V1 is crucial for conscious vision have been very useful in attempt to develop more concrete views about how sensory representations are constructed. I do not hesitate to admit that the model to be discussed is nothing more than a first attempt to relate the general idea of sensory canvas to the complex neuro reality and is severely restricted by my very limited knowledge about neuroscience (I am grateful for Gene Johnson for his patience while trying to teach me some basic facts about conscious brain).

5.3.1 Anatomical Structure Of The Cortex And Sensory Canvas Hypothesis

The anatomical structure and evolution of cortex inspires definite hypothesis about how brain constructs and realizes sensory representations at magnetic sensory canvas and how magnetic sensory canvas builds up motor actions. In order to avoid confusions I want to stress that sensory representations generated by brain are assumed to be symbolic representations assigning meaning to the raw sensory input and do not involve qualia, which in TGD Universe are most naturally assignable to the sensory organs.

Do primary sensory areas serve as gateways to the fundamental sensory canvas?

Is there single cortical magnetic body or several of them? Do various sensory areas define a hierarchy of magnetic bodies serving as sensory canvases ("sensory" is somewhat misleading here)? There are several arguments supporting the view that primary, and possibly secondary and tertiary sensory areas, but not necessarily higher areas, should be accompanied by separate magnetic bodies.

1. Computer metaphor encourages to consider the hypothesis that sensory representations and motor outputs have essentially the same character just like printout and monitor picture are different outputs of a same file in the case of a computer. First (with respect to the subjective time!) a rough sensory sketch is generated and then more and more details are added and the primary areas activate the final sensory representation just as in the case of motor output. As in the case of motor actions, higher levels of cortex simply select the activated sensory representation to be experienced consciously by us (binocular rivalry). The sequence of

quantum entanglements proceeding from the magnetic body down to the magnetic bodies of sensory organs selects what is experienced consciously by us. There is probably a hierarchy of experiencers each characterized by particular selections.

2. The intention for motor activity is realized as p-adic MEs connecting magnetic body by entanglement sequence to motor organs and induces directly action at this level (buy now-let others pay principle and precise targeted realization of intention). This quantum communication like aspect is accompanied by classical communications from magnetic body to cortex and in terms of nerve pulse patterns from cortex to lower levels. Intention can be also initiated at higher level than motor organs and in this case motor imagination is in question.

3. Mental images are entangled with the mediation of the negative energy projector MEs along along magnetic flux tubes connecting magnetic bodies together. Hierarchical sequences of mental images result in this manner, and sensory qualia become associated with various higher level mental images. MEs can be thought of as representing radiation propagating in the wave channel represented by the magnetic flux tube and being reflected repeatedly. MEs need not be only simple cylindrical prototype MEs but can be also curved: this means that the number of reflections need not be too high. Magnetic flux tubes are essentially guides for MEs so that they do not "lose their way".

4. The motor-sensory analogy might provide also other new insights. For instance, basic elements making possible several potential motor actions might exist simultaneously as subselves representing imagined basic modules of motor activity at the level of cortex. The sequence of quantum entanglements would then select the desired motor action, much like the sensory percept is selected in the sensory rivalry. This would be like building a program from a set of active modules selecting some subset of them or selecting one downwards path in a branching tree. The magnetic sensory representations associated with primary sensory organs without the higher level cognitive and symbolic associations could be seen as the counterparts of reflex actions.

Neural correlates of visual consciousness and motor-sensory analogy

The study of the neural correlates of visual consciousness reviewed in [J74] allows to study the reasonability of the primary sensory areas as gateway to sensory canvas hypothesis and its variants.

1. Evolutionary argument suggests that both primary sensory organs and various sensory areas are accompanied by magnetic bodies providing increasingly abstract symbolic and cognitive representations for the sensory input. The neurons at the higher sensory areas indeed become increasingly complex and have increasingly wider receptive fields. In particular, in the case of vision the neuronal receptive fields at V4 and higher areas are also dynamical and determined by the attentional level. Color/orientation information and the information about motion are treated separately in parvo and magno cellular pathways in V1, V2 and V3 but not in V4 (for the organization of the visual pathways see [J104]). These observations encourage the view that sensory areas define a hierarchy of separate magnetic bodies giving rise to more and more integrated conscious higher level representations of the sensory input. These representations define hierarchy of selves using the same brain and body.

2. The standard assumption about feed-forward hierarchy of the sensory areas leads to difficulties. For instance, in binocular rivalry of two competing visual stimuli feed to right and left eye, only the other stimulus is experienced at time. V1 and also V2 and V3 however contain neural representations of both stimuli. It has been also found that during the binocular rivalry the co-varying neural activities (seen by fMRI) in the extrastriatal visual cortex and in prefrontal cortex correlate with the subjective percept (rather than real stimulus) unlike the activity in V1 which represents both stimuli [J100]. The manner to understand this is that quantum entanglement sequences starting from the magnetic body proceed down to sensory organs and select from V1, V2 and V3 only the second stimulus.

3. It is known that neural activity in parietal and frontal regions is involved with the change of the dominating stimulus and that the activity in visual areas is not enough for visual

consciousness [J74]. Thus the presence of neural representations of both stimuli in V1 but conscious experience of only one stimulus would support the view that neuronal activity is *not* enough to generate our conscious experience. If the hierarchy of entanglements proceeds from our magnetic body to frontal lobes and from there downwards it is easy to understand why the activity in frontal lobes is essential for selecting the consciously experienced stimulus. Obviously the sensory-motor loop would have counterpart in much longer length scales.

4. V1 seems to be necessary for visual consciousness. Pascual-Leone and Walsh have studied the visual hallucinations induced by transcranial magnetic stimulation [J108]. The stimulation of V1 generates static and colored impressions whereas the stimulation of V5/MT generates moving non-colored phosphenes (in accordance with the fact that "where" type information processing is color blind and "what type" information processing at lowest levels is motion blind). This picture is consistent with the idea that the fundamental visual representations are realized at retinal magnetic bodies. The back-projections in question would be essential for the "qualiafication" of imagination during dreams and hallucinations.

5. The study also demonstrates that the stimulation of V1 *after*, rather than before, the stimulation of regions V5/MT sending feedback to V1 can prevent the generation of hallucination. Even more, [J88] describes a case in which patient has lost visual consciousness when V1 is not intact. There is indeed a strong neural feedback to V1, V2 and V3 from the higher visual areas V5/MT and area V1 is activated simultaneously with MT in macaque. These findings are in conflict with what one might expect if sensory processing proceeds in strictly feed-forward manner. The necessity of V1 for our visual consciousness is obvious if entanglement sequences go through V1 down to the level of retinas. Feedback would also make possible "coloring" of the sensory map during ordinary wave-up experience. Perception would be creative act already at the level of sensory organs.

6. The timing of the interactions in the visual areas provides further hints about how sensory representations are constructed. According to [J88] that early activation of V1 by magnocellular neurons in LGN occurs 20 ms earlier that the activation by parvocellular neurons. At this time also the feedback from V5/MT arrives to V1. This suggests that sensory map is constructed by making first a rough sketch using the sensory input from the magnocellular pathways (motion and position). For about 20 milliseconds later follows the coloring of the sensory map as well as the association of the higher level features to the map. This order is is consistent with the fact that highly developed parvocellular pathway is a newcomer in the evolution and that the information involved is not so vital for survival. Thus V1 would act as an effective "active blackboard" as has been suggested [J88] and by the sensory-motor analogy in TGD framework.

5.3.2   EEGAnd Sensory Canvas Hypothesis

The general qualitative features of EEG seem to conform with sensory canvas hypothesis and it seems possible to make relatively concrete suggestions for EEG correlates of sensory qualia, cognition and long term memories.

Why the endogenous magnetic field corresponds to.2 Gauss?

For years I erratically believed that the magnitude of the magnetic field assignable to the biological body is $B_E = .5$ Gauss, the nominal value of the Earth's magnetic field. Probably I had made the calculational error at very early stage when taking Ca^{++} cyclotron frequency as a standard. I am grateful for Bulgarian physicist Rossen Kolarov for pointing to me that the precise magnitude of the magnetic field implying the observed 15 Hz cyclotron frequency for Ca^{++} is .2 Gauss and thus slightly smaller than the minimum value.3 Gauss of B_E. This value must be assigned to the magnetic body carrying dark matter rather than to the flux quanta of the Earth's magnetic field. This field value corresponds roughly to the magnitude of B_E at distance 1.4R, R the radius of Earth.

Dark matter hierarchy leads to a detailed quantitative view about quantum biology with several testable predictions [K44]. Number theoretical arguments suggest a general formula for

the allowed values of Planck constant [K46] $h_{eff} = nh$ with n a product of two integers n_1 and n_2. The values of integers for n_i which the quantum phase is expressible using only iterated square root operation are number theoretically preferred and correspond to integers n_i expressible as $n_i = 2^k \prod_n F_{s_n}$, where $F_s = 2^{2^s} + 1$ is Fermat prime and each of them can appear only once. The lowest Fermat primes are $F_0 = 3, F_1 = 5, F_2 = 17$. The prediction is that also n-multiples of p-adic length scales are possible as preferred length scales. The unit of magnetic flux scales up as $h_0 \to h_n = nh_0$ in the transition increasing Planck constant: this is achieved by scalings $L(k) \to nL(k)$ and $B \to B/n$.

$B_E = .5$ Gauss corresponds to flux quantum for $L(169)$ for ordinary value of Planck constant. $B = .2$ Gauss would correspond to a flux tube radius $L = \sqrt{5/2} \times L_e(169) \simeq 1.58 L_e(169)$, which does not correspond to any p-adic length scale as such for $h_{eff} = h$. $k = 168 = 2^3 \times 3 \times 7$ with $h_{eff} = nh$, $n =_F 1 = 5$ would predict the field strength correctly as $B_{end} = 2B_E/5$ and predict the radius of the flux tube to be $r = 18$ μm, size of a large neuron. Furthermore, the model for EEG forces to assume that also a field $B_{end}/2$ must be assumed and this gives the minimal flux h_5. Note that $n = 5$ is the minimal value of n making possible universal topological quantum computation with Beraha number $B_n = 4cos^2(\pi/n)$ equal to Golden Mean [K6].

Evolution as emergence of lower EEG frequency scales: dark matter hierarchy

Sensory canvas hypothesis combined with the scaling law suggests an entire hierarchy of sensory canvases. One must however keep mind open for the possibility that the flux tubes of Earth's magnetic field define only single sensory magnetic canvas.

A firm prediction is that evolution should correspond to the emergence of higher level selves characterized by decreasing EEG frequency scales. There are two hierarchies involved. Dark matter hierarchy and p-adic length scale hierarchy and both presumably correspond to evolutionary hierarchies.

Dark matter hierarchy correspond to a hierarchy of values of Planck constant coming for the most general option as ratios and products of two integers. The model for the hierarchy of generalized EEGs [K44] assigns to preferred levels of dark matter hierarchy a typical time scale identifiable as typical time span of memories. The hypothesis about evolution proceeding as the emergence of higher and higher levels of dark matter hierarchy at the level of personal consciousness is very natural.

Evolution as emergence of lower EEG frequency scales: p-adic length scale hierarchy

p-Adic length scale hierarchy defines a hierarchy at each level of dark matter hierarchy and one can ask whether also the emergence of increasingly longer p-adic length scales characterizes evolution.

1. Cerebellar, retinal, and cortical rhythms

The p-adic time scales assignable with the basic rhythms associated with cerebellum, retina, and cortex increase in this order and are consistent with the hypothesis that higher evolutionary levels corresponds to longer p-adic time scales.

1. The fact that the dominating rhythm in cerebellum is about 200 Hz supports the view that it corresponds to shorter p-adic length and time scale than cortex. The fact that cerebellum is responsible for the finer details of motor action is consistent with shorter p-adic time scale.

   If one assumes that 200 Hz rhythm is analogous to sensorimotor rhythm of 13 Hz (Na^+ cyclotron frequency) then scaling then the magnetic field at the field quanta involved should be $\simeq 16$ times stronger than B_{end}. Since B_{end} most naturally corresponds to the p-adic length scale $k = 169$ and magnetic flux $2h_5$, this field could correspond to $k = 169 - 8 = 161 = 7 \times 23$ (scaling down of thickness of flux sheets flux sheets) or $k = 169 - 4 = 165 = 5 \times 53$ (scaling down of the radius of the flux tube). The work of [I53, I55] provides support for the hierarchy of magnetic flux sheets of various thicknesses associated with chromosomes and favors $k = 161$ option.

2. The micro-tremor of retina corresponds to 80 Hz frequency and would relate naturally to 40 Hz thalamocortical resonance frequency if the magnetic field in question corresponds to

transversally scaled down magnetic flux sheets having $k = 167$ instead of $k = 169$. Note that $k = 167$ corresponds to the Gaussian Mersenne $(1 + i)^{167} - 1$.

3. Primary sensory areas are dominated by 40 Hz frequency. Lowest frequencies such as hippocampal theta are in turn associated with long term memory which corresponds to high level mental function distinguishing sharply between humans and other species.

2. Why the interpretation in terms of spin flip frequencies does not work?

The original interpretation of cerebellar rhythm was in terms of some magnetic spin flip frequency. Representative examples of spin flip frequencies near cerebellar 200 Hz are $f_s(Na) = 222$ Hz, $f_s(Al) = 218$ Hz and $f_s(Mn) = 208$ Hz, $f_s(Co) = 199$ Hz and $f_s(Sc) = 204$ Hz. Co is obviously the best candidate.

The spin flip frequencies in EEG range (see the table 4) are $f_s(Cl) = 82$ Hz and $f_s(Rb) = 81$ Hz (80 Hz micro-tremor in retina); $f_s(K) = 39$ Hz and $f_s(Y) = 41$ Hz (both very near to 40 Hz thalamocortical resonance frequency); $f_s(Ag) = 34.2$ Hz, $f_s(Rh) = 26.6$ Hz (27 Hz resonance frequency in dog's cortex); $f_s(Ir) = 17$ Hz (narrow band in EEG [J111]), $f_s(Au) = 14$ Hz (the sleeping spindle frequency).

These interpretations are however excluded in the dark matter based view since the ions are assumed to be ordinary ions topologically condensed to dark matter space-time sheets defining λ^k-fold coverings of M^4 so that spin flip photons would be ordinary ones and their energies would be extremely low and much below the thermal threshold. Of course, one must be very cautious with this kind of statements since the ideas about dark matter are still just a collection of rules.

3. p-Adic length scale hierarchy as abstraction hierarchy

This picture suggest an abstraction hierarchy in which EEG frequency scale of projecting EEG MEs correlates with the abstractness of the feature associated with the point of sensory map. For instance, sensory qualia could correspond to gamma frequencies, in particular frequencies near 40 Hz; cognitive features to beta frequencies whereas alpha and theta and delta frequencies to the generation of the long term memories making possible the historical self. The frequencies involved with long term memory recall are expected to correspond to the time span of the memory characterized by the level of the dark matter hierarchy.

4. Objection against p-adic evolutionary hierarchy

If evolution corresponds to emergence of increasingly longer p-adic time scales in EEG, then the naïve application of ontogeny recapitulates phylogeny principle (ORP) suggest that gamma, beta, alpha and theta bands should emerge in this order during the development. This is not the case.

1. According to [J110], the wake-up EEG of infants before 3 months age consists of "fast" background activity. At three months posterior delta rhythm appears at 3-4 Hz and gradually shifts to 6-7 Hz during the first life year. According to [J43], binding related 40 Hz oscillations are evident at the age of 8 months. Also the contrast sensitivity of vision improves rapidly to adult level at this age: this conforms with the hypothesis that EEG is essential for the construction of the sensory representations.

2. According to [J68], [J68], for infants the counterpart of the alpha band appearing in darkness is the occipital rhythmic activity in the range $5.2 - 9.6$ Hz with peak frequency at about 7 Hz and increases gradually. The frequency band $6.0 - 8.8$ Hz with gradually increasing peak frequency at about 7 Hz is activated during visual attention and seems to be the counterpart of sensory-motor rhythm of about 13 Hz of adults. It would be interesting to know whether the sensorimotor rhythm is eventually established via a continuous shift of this band or not.

A direct correlation between body size and frequency scale of the sensory-motor frequency band suggests itself. This might be understood if magnetic flux tubes in the somatosensory part of the sensory canvas get gradually stretched during the growth so that the increasing distances of the body extremities from head are coded by increasing magnetic transition frequencies. This picture seems to contradict the idea about p-adic evolutionary hierarchy. In TGD framework one must however seriously consider the possibility that the lowest EEG bands relate

with the higher level collective and multi-brained sensory representations. These higher level selves could be especially alert during sleep since the entire information processing capacity used for the sensory and motor activities during wake-up state would be freely available. This suggests also a resolution of the objection against p-adic evolutionary hierarchy.

The work of Jaynes inspires the idea about child as a small bicameral nursed by the higher collective levels of consciousness. The location of the sensory motor and alpha rhythms in theta band could indeed be seen as an indication for a kind of magnetic nursery provided higher level magnetic selves and their presence would not corresponds to the infant's consciousness but to the consciousness of the "magnetic nurse". Rather interestingly, according to Jaynes [J90] sitting in mother's lap can induce EEG in infants not possessing stable EEG yet. An interesting question is whether mother's EEG shows a correlation with that of infant and whether it deviates from ordinary EEG in theta band.

The TGD based model of EEG to be discussed in detail later predicts that EEG consists of two copies so that ordinary alpha band has a scaled down copy around 5 Hz. The scaled down copy of EEG is predicted to dominate during sleep. The 7 Hz rhythm in the infant EEG could be interpreted as the scaled down counterpart of the sensorimotor rhythm identifiable in terms Na^+ cyclotron frequency. Infants would be in a state of consciousness analogous to sleep state as far EEG is considered: this of course conforms with the magnetic nursery hypothesis.

EEG rhythms in contrast to evoked and event related potentials

Evoked and event related potentials are believed to be associated with the neuronal activities generated by the sensory stimuli and it seems that they must be distinguished from the narrow frequency bands associated with the sensory and cognitive representations. Indeed, both evoked potentials associated with simple stimuli and event related potentials accompanying more complex stimuli have temporal structure which clearly reflects the propagation of nerve pulses along various parts of brain and one can assign to the peaks of the evoked potentials various a anatomical correlates in the neural pathways involved [J121].

The time-scale systematics for the evoked and event related potentials conforms with the idea of self hierarchy. For instance, brain stem responds to simple auditory stimuli like clicks in time scale is 10 ms: the corresponding frequency is 100 Hz, which is the dominating EEG frequency in brain stem. For cerebellum the corresponding rhythm is about 200 Hz and cerebellum indeed takes care of micro-temporal regulation of motor actions. For higher regions of brain the time scale of event related potentials is typically about 100 ms: this correspond to the time scale of 10 Hz and time scale of memetic code. For instance, at V4 activity starts 100 ms after the onset of the visual stimulus and is peaked around 135 ms.

A good example of an event related potential (ERP) is P300, which is a large positive amplitude ERP following an improbable target in the sequence of repeated target stimuli: P300 occurs with the latency of 300 ms for young adults and for simple stimuli. P300 is preceded by a negative potential called N2 which presumably corresponds to the conscious detection of the target stimulus whereas P300 probably represents the use of this information to update the model about world. N2 contains also information about novelty of the stimulus and the difference of N2 for standard stimulus and novel stimulus is called mismatch negativity.

Coherence of EEG and sensory canvas hypothesis

If the EEG measured at skull relates closely to the sensory representations, it must inherit high coherence from the high coherence of the sensory landscape. Also fractal like hierarchy is predicted. At higher frequencies associated with sensory representations in shorter length scales, coherence should be restricted in shorter range. Indeed, according to [J111], the coherence length for EEG at skull is present and measured by using 10 cm as a natural unit. This coherence could reflect the correlations between neural activities in various parts of brain but it is not at all obvious whether the timing of neural ionic currents can be so sharp that destructive interference cancelling the correlations EEG level does not occur.

According to [J111], very complex structures of coherence in bands around 3, 5 and 7 Hz and 13, 15 and 17 Hz are definitely inconsistent with simple dipole models for the generation of EEG patterns. The findings are however consistent with the view that several distant regions of

cortex can project features to the same point of a sensory map and that the coherence reflects the coherence of the sensory map. Coherence regions could naturally correspond to the objects of the perceptive field. The high coherence in the band $4 - 5$ Hz during mental calculations [J111], which certainly represent abstract information processing and involve also long term memory in an essential manner, supports the view that abstract long term memories correspond to lowest EEG bands at 3, 5 and 7 Hz. According to [J111], also increase of coherence between prefrontal and posterior cortical association areas have been reported during working memory retention in the range $4 - 7$ Hz.

The coherence lengths for EEG inside cortex are generally much shorter and complex patterns are encountered. Coherence length of order 2 cm is associated with cortical EEG structures which Freeman introduces as basic units of EEG activity [E3] and calls mesoscopic level of sensory processing. Note that also retina has same size as the mesoscopic structures. Perhaps it is not accident that this length scale corresponds to the highest ionic cyclotron frequencies in Helium period.

EEG synchrony and negentropic entanglement

If one accepts the vision about life as something in the intersection of real and p-adic worlds 40 Hz EEG synchrony can be interpreted as a correlate for the generation of negentropic entanglement (see **Fig.** `http://tgdtheory.fi/appfigures/cat.jpg` or **Fig. ??** in the appendix of this book) between cortical neurons. Before proposing this interpretation let us first describe the experimental findings of a finnish neuroscientist Antti Revonsuo [J20].

1. Findings

The interpretation for 40 Hz EEG frequency inspired by the binding hypothesis is as a synchronizing frequency necessary for the generation of unified percepts. This hypothesis has been studied using auto-stereograms [J20]. There was no detectable difference in the power spectrum at 36-44 Hz range in the situation when auto-stereogram was experienced as a set of random dots as compared to the situation when it was perceived as a coherent, symmetrical gestalt. The situation was same also in 8-13 Hz and 13-20 Hz beta bands. The finding is consistent with the place coding hypothesis.

On the other hand, when the conscious percept was transformed from a random set of points to a coherent gestalt, there was a detectable increase in 40 Hz power in the occipital and right posterior sites for EEG electrodes in a time window 500-300 ms before the unified percept was reported. There could be also some time lapse between the unified percept and the report about it but probably this cannot explain the entire lapse. No increase of power in beta bands was detected: this might be due to the fact that the widths of the measured bands are much wider than the widths of the narrow sub-bands reported masked by other EEG activity according to [J111]. Note that in the model for a hierarchy of EEGs based on dark matter hierarchy beta band correspond to data communicated to the magnetic body [K44].

That the change in activity is associated with the emergence of a new percept suggests that the temporary increase of the EEG power could be assigned to the communications of the forming percept to the magnetic body.

2. Interpretation in terms of generation of negentropic entanglement

A fresh view about what really happens during 40 Hz synchrony came with the realization that negentropic entanglement is possible in the intersection of real and p-adic worlds. The generation of negentropic entanglement between two sub-selves means that the corresponding mental images are fused [K113, K70]. The process is experienced by the fusing sub-selves as an expansion of consciousness whereas consciousness is lost when when bound state entanglement is generated. Also the meditative states begin with enhanced 40 Hz activity and the interpretation would be same. Quite generally, the generation of negentropically entangled neuron groups could be a correlate for the emergence of a new idea or a new holistic pattern emerging from a chaos. Synchronous firing would be a natural correlate for the synergic state resulting in this manner. The paradoxical looking reduction of the oxidative metabolism associated with 40 Hz firing could be seen as a signature of reduced dissipation when dissipating ensemble of neurons forms a single quantum coherent system.

What could then be the interpretation of the 300-500 ms time scale and synchronous firing in TGD framework?

1. If one assumes that only brain is involved, one must answer whether the new percept emerges after such a long time period. One would naïvely expect that negentropic entanglement immediately gives rise to the percept. Negentropic entanglement however means that a quantum superposition of several alternative percepts is involved. In the beginning the new percept is present with only small probability so that one would only know that the moment of eureka is quite near (this is indeed the experience that one has) and in the final situation it dominates but not completely since it requires conscious effort to preserve the percept.

2. Also magnetic body should be involved in TGD framework. The natural question is "Why this synchronous neuronal firing?". The natural answer would be that it allows to communicate the new percept as a consequence of a generation of negentropic entanglement to the magnetic body. The frequency scale of 40 Hz corresponds to a time scale of 25 milliseconds and corresponds to a length scale involved is about $.75 \times 10^7$ m, a good candidate for the size of the part of the magnetic body involved. This time scale is much shorter than 300-500 seconds. If the layer of the magnetic body in question corresponds to the fundamental 100 millisecond time scale assignable to electron as is natural in case of sensory percepts, the time lapse could be essentially due to the communication. If one takes the time scale literally the value of Planck constant which is about 3 to 5 larger than its standard value would suggest itself. Of course, the development of the percept from a fuzzy inkling to the final eureka could involve several communication loops between brain and magnetic body so that the interpretation as a lapse due the slowness of communications need not be inconsistent with the first interpretation.

3. The time scale 300-500 ms could characterize the duration of negentropic entanglement but this is not necessarily the case since negentropic entanglement would be un-necessary after the percept has been represented symbolically so that one knows what is lurking behind the chaos.

Narrow EEG bands and sensory canvas hypothesis

Sensory canvas hypothesis predicts the existence of narrow EEG bands corresponding to the magnetic transition frequencies varying in the range determined by the thickness range for the magnetic flux tubes involved with the sensory representation. The most natural candidates for the magnetic transition frequencies are cyclotron frequencies and their harmonics. There is indeed evidence for this kind of bands [J111].

1. The best known band is alpha band around 11 Hz and has width of order 1 Hz. From this one can conclude that the relative variation of the magnetic field along magnetic flux tubes and thus magnetic flux tube area in the radial direction is roughly 10 per cent so that the radius would vary about 3 per cent. The fact that alpha band at 11 Hz becomes active when eyes are closed is consistent with the interpretation that alpha band corresponds to cyclotron frequencies of bosonic ions and to the motor control by rather than sensory communications to the magnetic body. The activation of the alpha band is also associated with the generation of meditative and "creative" states of mind. Hence one cannot exclude the possibility that alpha band activation corresponds to the projection of some information to the possible multi-brained sensory/cognitive representations associated with higher level collective selves.

2. Besides alpha band Nunez mentions also narrow sub-bands at 3, 5 and 7 Hz at delta and theta range, as well as sub-bands at 13, 15 and 17 Hz in beta band [J111]. That beta disappears when eyes are closed conforms with the interpretation of these bands as being associated with sensory communications to the magnetic body. Hence these bands might be associated with the assignment of cognitive features to the points of the sensory canvas. Indeed, the evolutionary hierarchy sensory representations$\rightarrow$ cognitive representations$\rightarrow$ long term memories involving time like entanglement and making possible historical self, suggests this.

3. 40 Hz band has a width of about 8 Hz, contains several cyclotron frequencies, is associated with the primary sensory areas and disappears during sleep. This suggests that also this band is involved with the projection of the sensory qualia to the sensory canvas. The information about narrow sub-bands of EEG during hypnagogic states (the state between wake-up and sleep involving sensory hallucinations), during the schizophrenic hallucinations and hallucinations generated by sensory deprivation, and during lucid dreaming could provide interesting constraints on the possible sensory quale-EEG frequency correlations.

4. A well motivated guess is that 3, 5 and 7 Hz bands do not correspond directly to the sensory qualia experienced by our magnetic body. Hippocampal theta band (which actually extends from about 4 to 12 Hz) could contain these narrow bands and be involved with the assignment of abstract features, such as concepts and verbal associations and emotions, to the sensory map crucial for the memories. The fact that alpha and theta waves are important during this period suggests that alpha and theta frequencies are involved with the generation of episodal memories.

Whether the same frequency must be present during memory recall as during the generation of the memory, depends on the model of memory recall. According to the simplest model, memory recall means that an object in the sensory canvas of the geometric past is activated and temporal quantum entanglement mechanism allows us to share the experience. This does not require that the EEG frequency involved with sensory projection is generated in the brain which remembers. Of course, the formation of memory about recalled memory could generate this frequency.

5.3.3   How To Test The Sensory Canvas Hypothesis

In this subsection some tests for the new vision about sensory canvas hypothesis are proposed and some astrophysical phenomena possibly supporting the basic assumptions behind the new view are considered. The magnetospheric sensory representations associated with Mother Gaia, as opposed to the sensory representations realized at the personal magnetic body, are discussed in [K62].

Some simple tests

One could try to disturb the magnetic flux tubes or MEs responsible for the projection of the visual map to the external world *outside* the body somehow. If the visual experience is modified dramatically, one has an experimental argument supporting the new view. One could perhaps induce also magnetic quantum phase transitions outside the body by stimulating the super-conductors at magnetic transition frequencies and perhaps generate in this manner visual hallucinations. One could generate weak magnetic fields of roughly the same strength as the fields associated with the magnetic canvas and thus superposing with them. Slow modulations of the magnetic fields in these flux tubes might be possible so that cyclotron frequency scale changes and the objects of the perceptive field would be experienced to either contract or expand. Unfortunately (from the point of view of empirical testing), if sensory images are of order ME wavelength $L = c/f$, the sensory images might be extremely stable against perturbations.

One could also study what happens for the vision if the magnetic materials in brain or retina are not present in normal amounts. Or what happens when there is external magnetic field perturbing the magnetic field of Earth inside retina or cortex so that the compass defining the inertial reference frame does not function properly. Does this lead to a sensations associated with dizziness? Could the removal of Earth's magnetic field induce this kind of sensations or affect the visual experience? Probably this is not the case. The general model for EEG predicts that the magnetic flux quanta carrying dark matter responsible for sensory representations and motor control are present even if Earth's magnetic field is cancelled.

Tests for place coding

The hypothesis that EEG frequencies in narrow EEG bands code for the distance of an object of perceptive field can be tested. If subject person directs attention to a moving object of the perceptive field, the peak frequencies inside the narrow EEG bands responsible for the place-coding should shift. The detection of EEG activity in V1 when percept changes in binocular rivalry would

support the existence of strictly non-neural correlates of visual consciousness. Negative energy MEs are responsible for the entanglement, and one must ask what it is to detect negative energy MEs. MEs generate coherent light and phase conjugate laser waves at ELF frequencies are what comes in mind first. It is not at all obvious to me how one could observe these. The breakdown of second law in appropriate time scale might be one correlate for the presence of negative energy MEs.

How to test the hypothesis that primary sensory representations occur at the level of sensory organs?

That retinas are involved with the attention is known for some time: directing the attention to an object of the visual field does not necessarily imply directing the gaze to the object [J105]. The amplification of the back-projections from frontal lobes to the part of retina in question is enough, and if the feedback exceeds a critical value the direction of the gaze is changed. This suggests that the mental image of the object of the perceptive field is realized at the retina and corresponding magnetic body and directing of attention to it feeds metabolic energy to this mental image. If the fundamental visual representation occurs at the level of retinas, the selection of the visual percept in the visual rivalry might be detectable at the level of retinas.

80 Hz frequency is known to be associated with retinas, and one can wonder whether this would determine the size of the magnetic body associated with retina (the size would slightly below Earth radius!). It would be worth of testing whether the pattern of 80 Hz activity associated with retinas correlates with the selection of the sensory percept say in the case of sensory rivalry: certainly this is not what standard neuroscience would suggest but would be worth of testing.

5.4 Could brain be represented as a hyperbolic geometry?

There are proposals that neuronal systems in brain could have hyperbolic geometry [J40] (`http://tinyurl.com/ybghux6d`) in the sense that neurons could be mappable to a 2-D lattice like structure representable in terms of to 2-D hyperbolic geometry H^2. A concrete identification as a lattice-like structure in H^2 would not be in question.

5.4.1 A concrete representation of hyperbolic geometry cannot be in question

The tessellations of P^2 represented as Poincare disk have large density of points near the boundary. The concrete geometry of the cortex could very roughly correlate with the geometry of near the boundary of Poincare disk or even boundary sphere of 3-D Poincare ball representing 3-D hyperbolic space H^3. A rather abstract representation based on statistical properties of the network formed by the neurons would be in question. If a genuine geometric representation as a tessellation of hyperbolic space exist it must be realized somewhere else than brain.

To see what is involved, note that the line element of Poincare disk is given by

$$ds^2 = d\eta^2 + sinh^2(\eta)d\phi^2 \ .$$

to be compared with the line element of ordinary disk given by

$$ds^2 = d\rho^2 + \rho^2 d\phi^2 \ .$$

For given neuron the size of the radial coordinate η of Poincare disk would correspond roughly to the number of connections it has, kind of popularity. For large values of radial coordinate η the circles of Poincare disk have radius proportional to η and circumference proportional to $sinh(\eta)$ increasing exponentially for large values of η whereas for ordinary disk both radial distance circumference would be proportional to ρ.

For the neurons of cortex, in particular pyramidal neurons, the image points would have large distance from the origin of hyperbolic space. The image points for neurons resembling each other would have small distance with respect to the angular coordinate of the Poincare disk. Since similar neurons can have large distances from each other at the level of brain, the representation must involve a map taking them close to each other.

5.4.2 Hyperbolic geometry and its tessellations

The standard representations for 2-D hyperbolic geometry are 2-D Poincare plane (`http://tinyurl.com/y8tnklz6`) and Poincare disk (`http://tinyurl.com/y8bcd6cv`). Poincare disk is claimed to be natural representation space for the lattice like structure of neutrons. These lattice structures of H^2 are known as tessellations.

Remark: There is a painting of Escher visualizing Poincare disk. From this painting one learns that the density of points of the tessellation increases without limit as one approaches the boundary of the Poincare disk.

The group $SL(X)$, $X = C, R$, consists of matrices $[a, b; c, d]$ with $a, b, c, d \in X$ satisfying $ad - bc = 1$. The modular group $SL(2, Z)$ acts subgroup of both $SL(2, C)$ and $SL(2, R)$. $SL(2, C)$ resp. $SL(2, R)$ forms a double covering of Lorentz group $SO(1,3)$ resp. $SO(1,2) = SL(2, R)$. $SL(2, C)/SU(2) = SO(1,3)/SO(3)$ defines 3-D hyperbolic geometry H^3 realized as $a = \sqrt{t^2 - x^2 - y^2 - z^2} = constant$ hyperboloid of future light-cone M^4_+ having $SO(1,3)$ as isometries. $SL(2, R) = SO(1,2)$ acts as isometries of H^2 realizes as hyperboloid of M^3_+. $SL(2, C)$ resp. $SL(2, R)$ acts as complex resp. real Möbius (conformal) transformations $z \to (az + b)/(cz + d)$, $ad - bc = 1$, of complex plane resp. upper half plane.

The modular group $SL(2, Z)$ acting as the subgroup of $SL(2, R) \subset SL(2, C)$ consists of matrices $[a, b; c, d]$ having integer valued elements satisfying $ad - bc = 1$. Alternative definition identifies the elements differing by sign (`https://en.wikipedia.org/wiki/Modular_group`) is a basic example of infinite discrete sub-group.

Modular group is representable as a free product $Z_2 * Z_3$ with generators S resp. T subject to relations $S^2 = I$ and $(ST)^3 = I$. Modular group has braid group B_3 of 3 braids as a universal covering group. Modular group has an infinite number of congruence subgroups $\Gamma(N)$ as subgroups. The diagonal elements of $\Gamma(N)$ satisfy $a \ mod \ N = d \ mod \ N = \pm 1$ and $c \ mod \ N = d \ mod \ N = 0$ so that the matrices are equal to $\pm I$ modulo N. There is also a hierarchy of subgroups $\Gamma_0(N)$ for which matrices are upper triangular matrices modulo N.

In TGD one has also p-adic length scale hierarchy with preferred p-adic primes $p \simeq 2^k$. Therefore the groups $\Gamma(p^n)$ are of special interest in TGD framework.

If replaces N with an extension of rationals, one obtains huge hierarchy of subgroups expected to be relevant in TGD framework. One can define the notion of integer also for the extensions of rationals. Algebraic integer is defined as a root of a monic polynomial $P_n = x^n + ...$ with integer coefficients. Also the counterparts of the groups $\Gamma(N)$ can be defined, in particular those associated with $N = p^n$.

H^n, $n = 2, 3$ allows infinite number of tessellations as left coset spaces $G \backslash H^n$ of $H^n = SO(1, n)/SO(1, 1)$. G is here some infinite discrete subgroup $G \subset SO(1, n)$ of $SO(1, n)$ such as $\Gamma(N)$. For ordinary sphere S^2 the analogs of tessellations are finite lattices and correspond to Platonic solids - tetrahedron, octahedron and cube, and icosahedron and dodecahedron. tessellations would therefore define hyperbolic analogs of Platonic solids.

The groups $SL(2, Z)/Z_N$ are finite groups. For $N = 3$ one obtains tetrahedral group and $N = 5$ gives icosahedral group. Both groups play central role in TGD inspired model of genetic code [L19, L75] but their origin has remained unclear. $\Gamma(N)$ is a normal subgroup $SL(2, Z)$ so that the coset space is group too: $SL(2, Z)/\Gamma(N) = SL(2, Z_N)$. One can represent the elements of group algebra $G(SL(2, Z))$ of $SL(2, Z)$ as entangled elements in the tensor product of $G(SL(2, Z)/\Gamma(N))$ and $G(SL(2, Z_N))$. Number theoretic state function reduction as a "small" state function reduction (SSFR) for elements of $G(SL(2, Z)))$ would project them to unentangled products of elements of $G(SL(2, Z)/\Gamma(N))$ and $G(SL(2, Z_N))$. Maybe genetic code could relate with $\Gamma(N)$ with $N = 3$ and $N = 5$.

5.4.3 Could magnetic body provide a concrete geometric representation for the tessellation of hyperbolic space?

In TGD framework magnetic body (MB) having an onion-like structure and carrying dark matter as ordinary matter labelled by effective Planck constant $h_{eff} = nh_0$, where n corresponds to the dimension of extension of rationals serving as a kind of IQ. Various quantum scales, in particular quantum coherence length are expected to be proportional to n so that algebraic extensions of

rationals define an evolutionary hierarchy with levels labelled by the dimension of extension. Space-time surface for given value of n can be regarded as a covering spaces with n sheets related by the action of Galois group of Galois extension acting as symmetry.

The question is whether one could generalize the hypothesis [J40] (http://tinyurl.com/ybghux6d) in TGD framework. In the sequel such a generalization replacing 2-D hyperbolic space with its 3-D counterpart and assuming that the hyperbolic tessellation is associated with MB of brain or of its subsystem considered. This generalization reduces to P^2 if one restricts P^3 to subspace P^2 and restricts $SL(2,C)$ ($SO(1,3)$) as symmetry to cylindrical symmetry $SL(2,R)$ ($SO(1,2)$). Cylindrical symmetry is natural to magnetic flux tubes and cylindrical magnetic flux sheets so that P^2 option might be more natural.

The notion of MB is extremely general and makes sense in all scales, and one can consider the possibility that the hyperbolic tessellations could provide a kind of universal for the MB of system responsible for cognitive representations.

5.4.4 Could regions of brain be mapped to tessellations of 3-D hyperbolic space defined by magnetic body?

The question is whether some 3-D lattice-like structures formed by neurons of brain or its subsystem could correspond to tessellations of 2-D or 3-D hyperbolic space H^3 realization as cognitive representations at the MB of brain having hierarchical onion-like structure correlating with hierarchical structure of brain. The tessellation would be defined by an infinite discrete subgroup G of $SL(2,C)$ such that elements are algebraic integers in the extension of rationals. The unit cells of the tessellation would be labelled by elements of G and would therefore define cognitive representation.

One can consider two basic options. Brain or its substructure as 3-D structure is mapped

1. either to a tessellation of H^3 at which $SL(2,C)$ acts as isometries,

2. or to a cylindrically to a tessellation of H^2 at which $SL(2,R)$ acts as isometries represented as upper half-plane or as Poincare disk where the action is as conformal transformation. One can consider also mapping to a complex plane compactified to Riemann sphere at which $SL(2,C)$ acts: now the action is however not as isometries but conformal transformations.

   The interpretation could be in terms of symmetry breaking selecting time axis and spin quantization axis as direction of cylinder.

Some basic facts

Consider first some basic facts about the possible role of 3-D hyperbolic space and its tessellations in TGD.

1. 3-D hyperbolic space H^3 representable as hyperboloid $t^2 - x^2 - y^2 - z^2 \equiv t^2 - r_M^2 = a^2$. a has interpretation as light-cone proper time and in TGD inspired cosmology it corresponds to cosmic time. 2-D hyperbolic space could be seen as subspace of H^3. Now infinite discrete subgroups of $SO(1,3)$ would define tessellations as lattice-like structures. They would serve as 3-D analogs of Platonic solids. I have proposed [K68] that they could explain the astrophysical objects a located along lines with redshifts coming as multiples of a basic redshift in terms of lattice-like structures in cosmic scales.

2. Brain region itself cannot correspond in any manner to a region of H^3 represented as $a = constant = a_0$ hyperboloid. MB of brain region might however do so. The mapping of brain region to the hyperboloid $a = a_0$ could be mediated by gravitational magnetic flux tubes which can be radial since the Kähler flux vanishes in good approximation and there is no conserved monopole flux. Only the cognitive representation as discrete points in extension of rationals would correspond to points of the hyperboloid.

   If MB participates in cosmological expansion assignable to CD, its size would scale up like a as also the cognitive representation associated with the tessellation, whose points would be labelled by discrete infinite subgroup G - say congruence group $\Gamma(N)$ for extension of rationals. In ZEO this means that the part of tessellation inside CD would approach to the

boundary of CD (or cd). The finite size of CD would however prevent the expansion to values of $a > T$, T is the size of CD define as the maximal radius of the intersection light-cones involved. It would also prevent MB from reaching the boundary of CD. One cannot therefore exclude cosmic expansion of MB.

3. One can challenge the assumption about cosmic expansion of MB. Quite generally, all known astrophysical objects participate in cosmological expansion by receding from each other as the cosmic redshifts show but do not experience cosmological expansion themselves. TGD solves this paradox by the assumption that cosmic expansion takes place as quantum phase transitions in which expansion occurs in rapid jerks, which correspond to reductions of length scale dependent cosmological constant Λ by a power of 2 if p-adic length scale hypothesis is accepted [L79] .

    There is evidence that even Earth has experienced this kind of expansion during Cambrian Explosion, which would have increased the radius of Earth by factor 2 [L62]. This would have been also a giant step in biological evolution as the multicellular life developed in the Earth's interior would have bursted to the surface of Earth and oceans would have formed. An interesting question inspired by the fractality of TGD Universe is whether one could see also the biological growth and development of organs and organelles as sequences of this kind of phase transitions.

    This situation might hold true also for MB so that also it should evolve by rapid jerks as the value of Λ is reduced.

4. In TGD space-times are surfaces in $M^4 \times CP_2$. In zero energy ontology (ZEO) they are 4-surfaces in causal diamond (CD), where one has $= cd \times CP_2$, where cd is diamond-like intersection of future and past directed light-cones.

    For light-cone M^4_+ one has a natural slicing is by using the hyperboloids $a = constant$. This slicing would define a natural time coordinate as analog of cosmic time. The usual linear Minkowski coordinates define a second natural natural slicing by $t = constant$ sections, where t is the linear Minkowski time.

    One can define the standard hyperbolic coordinates of M^4_+ by the line element

    $$ds^2 = da^2 - a^2(d\eta^2 + sinh^2(\eta)d\Omega^2) \ .$$

    $d\Omega^2 = d\theta^2 + sin^2(theta)d\phi^2$ is the line element of unit sphere S^2. η is the hyperbolic angle identifiable as analog of ordinary angle and having expression

    $$tanh(\eta) = \frac{r_M}{t} \equiv \beta$$

    having an interpretation as velocity $\beta = v/c$ n radial direction satisfying $\beta \leq 1$: one has $t = acosh(\eta)$ and $r_M = asinh(\eta)$.

About the precise correspondence between 3-D surfaces and H^3

What could the precise correspondence between 3-D surface giving rise to a cognitive representation of MB and tessellation of H^3 be?

1. The space-time surface representing MB is not hyperbolic space itself but could in some sense have discrete subgroup of $G \subset H^3$ as its symmetries: a possible interpretation would be as cognitive representations [L88, L76] consisting of points of H with coordinates in extension of rationals defining the adele [L51, L50]. The lattice-like structure associated with 3-surfaces could be mappable to this kind of hyperboloid for some value of a.

    Could the part of MB representing sub-system of brain in question be seen as an intersection of the with $t = T$ section of M^4_+ with the slicing of M^4_+ by $a = constant$ hyperboloids such that magnetic images of neurons as points of the tessellation of H^3 defining cognitive representation would belong to the intersection? For $t > T$ the 3-D structure would be preserved in good approximation.

2. The usual time=constant snapshot in M^4_+ satisfying $t = T$ intersects the hyperboloids with $0 \leq a \leq T$. The condition $t = acosh(\eta) = T$ gives $a = T/cosh(\eta)$ so that a indeed varies in this range. This gives for the radial M^4 coordinate $r_M = asinh(\eta) = Ttanh(\eta)$ giving $r_M \leq T$.

   It seems that this projection is 3-D analog of Poincare disk as a "Poincare ball" of radius $r_M \leq T$ with at least analog of hyperbolic geometry. At least the density of intersections with hyperboloids increases as one approaches light-cone boundary since the density of hyperboloids increases.

3. A tessellation of H^3 corresponds to the points $\{(asinh(\eta_n), \Omega_n)\}$. The lattice-like structure in E^3 for $t = T$ would correspond to points (r_M, Ω) in $\{Ttanh(\eta_n), \Omega_n\}$. The difference from the representation hyperbolic geometry as H^3 is that instead of $r_M = asinh(\theta_n)$ for H^3 one has $r_M = Ttanh(\eta_n)$ for the analog of Poincare disk. For small values of η one has $sinh(\eta) \simeq tanh(\eta)$ but not for large values so that E^3 is compressed to Poincare ball B^3.

   Neurons with large number of connections would correspond to points of tessellation with large values of η_n and similar neurons even if far away from each other would be mapped near to each other at spheres $\eta_n = $ constant surfaces (spheres for H^3 or circles for H^2).

   The discrete geometries for the magnetic image of neural sub-system as tessellations would naturally correspond to discrete subgroups of $G \subset SO(1,3)$ as analogs $G\backslash H^3$ of Platonic solids. As found, there is infinite number of them and concordance groups $\Gamma(N)$ ore of special interest. One obtains also their 2-D variants as 2-D planar slices consistent with the symmetries just like one can have 2-D lattices as sub-lattices of 3-D lattices in E^3.

   Remark: The elements of subgroup $G \subset SL(2,C)$ for given extension of rationals provide natural coordinates for the unit cells of tessellation, and can be used instead of $\{\eta_n, \Omega_n\}$.

4. The system could have a finite size due to finite light-velocity if it has resulted in an event analogous to Big Bang like event (TGD predicts a hierarchy of cosmologies within cosmologies and cd is geometrically analogous to Big Bang followed by Big Crunch). This option does not however look plausible at the level of visible bio-matter. At the level of MB this could be make sense and correspond to the emergence of a new onion-like layers to MB bringing in new scale of quantum coherence as CD.

   In the case of MB one can estimate the T from the assumption that EEG corresponds to communications between brain and particular layer of its MB. Schumann frequency 7.8 Hz corresponds to wavelength of $\lambda = 2\pi R_E$, R_E Earth radius. EEG alpha band is around 10 Hz and corresponds to a slightly shorter wave length lengths. If this frequency is realized as cyclotron frequency the corresponding part of MB should be of the order of Earth size. This would give $R \sim R_E$ and $T \leq R/c \leq .1$ s. The part of neuronal system considered could be the above described intersection corresponding to time $t = T$. After this no expansion would take place and the 3-D analog of Poincare ball would be preserved.

   Note that if MB would participate in cosmic expansion, one would expect that the frequency scale of EEG scales down like $1/a$, which is not observed. Different bands of EEG could however correspond to different values of $a = a_0$ defining different layers of MB.

The neuronal network has been assumed to be accompanied by flux tube network with flux tubes parallel to axons defining the "small" part of MB with size of order body size [L44, L61]. How the topology of this network correlates with the topology of the "large" part of MB with layers having size scales even larger than Earth size? Could the "small" networks at the level of biological body be representations of the "large" networks at the level of MB - or vice versa.

The higher level representations would re-organize the nodes of "small" flux tube networks by various criteria such as the number of connections to other nodes. Similar nodes - even distant ones - would correspond to points near to each other. Therefore similar neurons could be treated as coherent units with coherence induced from that at higher level. Synchronous firing would be the signature for nearness at the higher level. The hierarchy of layers of MB would perform basically classification of the objects of the system at the lowest level.

There is a huge number of possibilities for the cognitive representations corresponding to various values of N (in particular powers preferred prime p) labeling $\Gamma(N)$, to hierarchy of extensions

of rationals and the values of T possibly identifiable as roots of polynomials defining representation of layer of MB in M^8. Therefore one can hope that this vision could provide universal view about the anatomy of MB in relation to that of biological body (in very general sense).

The interpretation of the hyperbolic tessellations of neurons in terms of ZEO, $M^8 - H$ duality, and cognitive representations

This picture suggests an interesting connection to TGD based view about quantum measurement theory [L92], which actually extends physics to a theory of consciousness. Causal diamonds (CDs) have a key role in ZEO and hyperbolic geometry is very naturally associated with them. The notions $M^8 - H$ duality [L86, L83] could provide an explanation for the special value $t = T$, and tessellations could correspond to a particular cognitive representation [L88].

1. In zero energy ontology (ZEO) replacing ordinary ontology of quantum theory the notion of causal diamond (CD) plays a central role. CDs for a length scale hierarchy and CDs have sub-CDs. Space-time surfaces for given CD have ends at the upper and lower boundary of CD. In this picture the appearance of hyperbolic geometry at the level of MB would be very natural.

2. $M^8 - H$ duality [L86] states that space-time surfaces could be regarded either as algebraic surfaces in M^8 or as preferred extremals of action in $H = M^4 \times CP_2$ reducing to minimal surface satisfying infinite number of additional conditions. Otherwise the consistency of dynamics in H dictated by partial differential equations with algebraic dynamics in M^8 dictated by algebraic equations would not be possible.

   One can say that space-time surfaces are roots of an octonionic polynomial obtained as an algebraic continuation of a real polynomial with rational coefficients to octonionic polynomial. This in the sense that either imaginary or real part of P in quaternionic sense vanishes and gives rise to 4-D surface in the generic case.

3. A special prediction of M^8 picture is that besides 4-D surfaces as roots of algebraic equations also 6-D special brane-like solutions with topology of 6-sphere S^6 are possible. For these solutions both real and imaginary parts vanish. These solutions have counterparts in H, and their intersection with cd is $t = r_n$ ball, where r_n is the root of P.

4. I have called the moments $t = r_n$ "very special moments in the life of self" identified as evolution of zero energy state of self by "small" state function reductions (SSFRs) as analogs of weak measurements. Also the size of CD increases in this process in statistical sense and corresponds to the increase of clock time as a natural correlate of subjective time defined by the sequence of SSFRs.

5. Could the state of neuron system at $t = T$ correspond to $T = r_n$ as a root of polynomial P? Could these special moments correspond to rapid jerks in the cosmological expansion so that also the development of living organism would involve a sequence of them increasing the value of Λ. Presumably these jerks would occur at the level of MB and possibly induce those at the level of biological body. At the level o MB they could also correspond to a phase transition like events in the evolution of consciousness involving scaling up the size of MB.

   To summarize, the tessellations of H^3 or $E^1 \times H^2$ suggest a universal cognitive representations realized at the MB of the system. One would have hierarchy of p-adic length scales and extensions of rationals giving rise to hierarchies of tessellations defining cognitive representations at corresponding layers of MB. Living matter would be only a special case. In living matter EEG would define important hierarchies of tessellations but also other frequency ranges would do so.

5.4.5   Empirical support for MB as a carrier of information about state of BB

If the view about hyperbolic brain and body is true, an abstract plan of brain and BB would be realized at MB. There are several findings supporting this view and in the following two examples are described.

Salamander recovers after shuffling of its brain

In the lab, the neurons of the brain of a salamander were shuffled like a pack of cards. The salamander however recovered and preserved its memories (identified as learned behaviors) [J107]. In [K88, K90] this finding was considered as a support for the view that the brain is analogous to a hologram (TGD Universe can be seen as a conscious hologram [K22]). It seems, however, clear that a single neuron cannot represent the information content of the entire brain. However, if memories are represented by the images of neurons at the level of the MB, the shuffling of neurons has no effect on memories as the experiment indeed demonstrated. Neurons would be analogous to RAM in computer science.

A chordate able to regrow all of its organs if dissected into three pieces

The popular article "Polycarpa mytiligera can regrow all of its organs if dissected into three pieces" `https://cutt.ly/SndWg8l` tells about an extraordinary biological discovery.

The creature known as Polycarpa mytiligera is a marine animal commonly found in Gulf of Eilat that is capable of regenerating its organs. The surprising discovery was that the animal can regenerate all of its organs even when dissected into three fragments.

Such a high regenerative capacity has not been detected earlier in a chordate animal that reproduces only by sexual reproduction. In the experiment, the researchers dissected specimens in a method that left part of the body without a nerve center, heart, and part of the digestive system. Not only did each part of the creature survive the dissection on its own, all of the organs regenerated in each of the three sections.

This is highly interesting challenge for TGD. The information about the full animal body was needed for a full generation. How it was preserved in dissection? Was genetic information, as it is understood in standard biology, really enough to achieve this?

1. In TGD inspired quantum biology magnetic body (MB) carrying dark matter as $h_{eff}/h_0 = n$ phases is the key notion. h_{eff} is an effective Planck constant defining the scale of quantum coherence. n is dimension of extension of rationals defined by a polynomial defining space-time region, and serves as a measure for algebraic complexity and serves as a kind of IQ. MB with high IQ defined by n serves as the master of BB controlling it and receiving information from it. The layers of MB also define abstracted representations of BB.

2. If BB suffers damage, the information about BB is not lost at MB and MB, which carries abstracted representations about BB and able to control BB, could restore BB partially. Healing of wounds would be the basic example. A more dramatic example about healing was discovered by Peoch: the neurons of the salamander brain can be shuffled like cards in a package but the animal recovers.

   Indeed, since nothing happens to the MB of salamander or Polycarpa Mytilera, recovery is in principle possible. The new finding gives additional support for MB as a carrier of the biological information.

One can also make questions about the recovery process itself. Could recovery be seen as a self-organization process of some kind?

1. In the TGD framework, quantum measurement theory relies onzero energy ontology (ZEO) and solves its basic problem. The basic prediction is that in the TGD counterparts of ordinary state function reductions ("big" SFRs or BSFRs) time reversal takes place. In small SFRs (SSFRs) identifiable as analogs of "weak" measurements, the arrow of time is preserved. ZEO makes it also possible to understand why the Universe looks classical in all scales although BSFRs occur in all scales at the dark onion-like layers of MB controlling the lower layers with ordinary biomatter at the bottom of the hierarchy.

2. Time reversed dissipation after BSFR looks like self-organization from the perspective of the outsider with a standard arrow of time, called it briefly O, and would bea basic self-organization process in living systems. In dissipation gradients disappear but in time-reversed dissipation they appear from the perspective of O.

3. This makes possible also self-organized quantum criticality (SOQC), which is impossible in standard thermodynamics because criticality by definition means instability. The change of the arrow of time changes the situation from the perspective of O since the time reversed system tends to approach the criticality. Homeostasis would rely SOQC rather than on extremely complex deterministic control programs as in the computerism based picture. Change the arrow of time for a subsystem and let it happen. Very Buddhist approach to healing!

4. The change of the arrow of time would be also central in the healing processes and also regeneration.

5.5 DMT experiences and hyperbolic geometry

I received a link to a highly inspiring talk about a modelling of DMT induced experiences in terms of 2-D and more generally 3-D hyperbolic geometry. The title of the talk (see `https://zpr.io/7Bzbagjrk7LE`) was "DMT and Hyperbolic Geometry"". The talk was by a person using the name "Algekalipso" and I understand that the person in question is Andres Gomez Emilsson. The organization in question is Qualia Research Institute (`https://cutt.ly/fGO5D9W`). There is also article by Emilssson (`https://cutt.ly/YGO5Qrk`) with essentially the same content.

5.5.1 Can one characterize DMT experiences by using temperature like parameters

The question posed in the beginning of the talk was whether there could exist parameters analogous to temperature allowing a general qualitative understanding of the nature of the DMT and more general psychedelic experiences. The proposal was that the DMT experience could be characterized by two parameters.

1. The first parameter characterizes how "hyperbolic" the visual field is and is identifiable as the curvature of the hyperbolic space. The idea is that during a DMT trip the experienced 3-space is not Euclidean but hyperbolic. This kind of geometry has been proposed as an effective statistical geometry of the brain in which functionally similar neurons distant from each other are close to each other [L99].

   In the TGD framework, this effective geometry could correspond to a real hyperbolic geometry of 3-D hyperbolic space playing a key role in TGD and assignable naturally to the magnetic body (MB). Besides ordinary visual input also the projection of objects of H^3 to the usual Euclidean space E^3 would be experienced so that the experience would be "multiverse" experience.

   In the TGD Universe, the space-times are minimal surfaces apart from singularities analogous to frames of soap films [L113] and their basic aspect is local saddle point property possessed also by hyperbolic spaces. Maybe DMT experiences make it possible to visually perceive 3-surfaces as objects in H^3. Also the usual vision corresponds to hyperbolic vision but with a small value of the H^3 curvature.

2. The second parameter would characterize the complexity of the experience and could in the TGD framework correspond to algebraic complexity associated with the extension of rationals determined by the polynomial determining a given space-time region by $M^8 - H$ duality [L96, L97].

   The value $h_{eff} = nh_0$ of the effective Planck constant, which can be larger than h, would correspond to the dimension n of the extension of rationals and serve as a universal IQ. Dark matter would correspond to phases of ordinary matter with $h_{eff} \neq h$.

   As the IQ increases, the experience transforms from simple to complex and eventually chaotic since the experiencer is not able to make sense of it. Under some assumptions this would relate to the formation of Julia set type fractals.

The model also leads to a progress in the interpretation of TGD. In particular, a geometric interpretation of p-adic length scale hypothesis [K76, K64] suggesting that p-adic length scale is accompanied by much shorter length scale of order CP_2 length scale finds an interpretation: p-adic length scale would correspond to the Euclidian scale defined by a hyperbolic length scale naturally emerging for hyperbolic tessellations.

5.5.2 TGD based model for DMT experiences

I have already earlier developed a TGD based model [L99] for the finding that the brain seems to obey an effective statistical geometry which is hyperbolic in the sense that neurons which are functionally near to each other have a short distance in this geometry. In the sequel a TGD based model for DMT experiences relying on hyperbolic geometry and based on the ideas already outlined is developed.

About hyperbolic spaces

First some mathematical background.

1. Hyperbolic 3-space H^3 is a generalization of 1-D hyperbola of 2-D space-time as a curve defined by condition $t^2 - x^2 = a^2$ but with its metric being induced from the 2-D Minkowski metric $ds^2 = dt^2 - dx^2$. By performing all possible rotations of this 1-D hyperbola one obtains H^3.

2. In particle physics H^3 corresponds to mass shell $E^2 - p^2 = m^2$ and in cosmology to cosmic time identifiable as $a^2 = t^r - r^2$ in $M^4 \subset M^4 \times CP_2$. a defines Lorentz invariant cosmic time and is therefore analogous to absolute time invariant under Lorentz boosts which do not affect the tip of the light-cone. It is not invariant under translations however.

   In the TGD framework H^3 has a central role and plays a key role also in the model of the brain involving the notion of magnetic body (MB). One could say that cognitive and sensory representations are realized at the intersection of MB with H^3.

3. The value of cosmic time a characterizes the curvature of H^3. The curvature is proportional to $1/a^2$ and the smaller the value of a, the larger the curvature and "hyperbolicity". As a decreases, one approaches the analog of the Big Bang with infinite curvature. As a increases, one approaches flat E^3 in an infinite future. Cosmic evolution proceeds from the Big Bang to the future whereas DMT trip would be a travel towards the moment of Big Bang. One can of course ask whether trips could also be in the opposite time direction.

4. The lecture (see also the written version) contains a nice description of hyperbolic geometry. In particular, the volume of a ball in H^3 increases exponentially as a function of its radius and this means that H^3 has a lot of volume. This might be very relevant for memory storage. This can be easily understood from the visualization in terms of real hyperboloid.

5. The counterpart of plane E^2 of E^3 in H^3 is 2-D hyperbolic space H^2 and Poincare sphere gives a good view about what the projections of the tessellations of H^2 look like when projected to E^2. The radial size for the basic unit of tessellations decreases with the distance from the origin whereas the region around the origin looks like E^2.

   Note that one particular tessellation, known as icosa-tetrahedral tessellation, plays a key role in the TGD based view about genetic code implied by the notion of bioharmony [L101], which relies on icosahedral and tetrahedral Hamiltonian cycles [L108].

6. The hyperbolic geometry H^2 embedded locally in E^3 has the saddle property meaning that in one direction the observer is at the bottom of the valley and in another direction at the top of the hill. This property has analog also at the level of abstract geometry: geodesic lines diverge very rapidly since the curvature scalar is negative: for spheres they converge.

7. By their negative curvature, H^3 and H^2 allow tessellations (analogs of lattices in E^3 and E^2) which are not possible in E^3. For instance. 7-polygons are possible. The number of tessellations is infinite whereas in E^2 only 17 wall papers are possible.

8. Hyperbolic analogs of plants are mentioned as fractals.

A possible interpretation of DMT experiences

DMT experiences could reflect both the relationship between the geometries of hyperbolic 3-space and Euclidian 3-space represented as 3-surfaces of Minkowski space and the algebraic complexity assignable to the tessellations of H^3.

1. DMT trip as travel backwards in cosmic time

It was already mentioned that the proper time parameter a and algebraic complexity characterized by extension of rationals could characterize DMT experience. The increased complexity in turn means approach to apparent chaos since it is not possible to comprehend too high complexity. The following description is what I understood from the representation of Emilsson. I have not personally made DMT trips except spontaneously decades ago. This experience was so impressive that I got a passion to understand conscious experience from a quantum physics point of view.

1. For small DMT does, the visual experiences correspond to patterns in plane $E^2 \subset E^3$, which can be regarded as plane $H^2 \subset H^3$ for large value of a and thus small curvature.

   The lattives of E^2 (17) called wallpapers serve as a background for the visual field. As if one would be perceiving two different worlds simultaneously. The lattices can be dynamical and pulsate. This kind of experience was part of the "Great Experience" decades ago.

2. As the DMT dose increases, the value of a decreases and one moves towards the Big Bang, so to say. In TGD and TGD inspired theory of consciousness, causal diamonds (CDs), identified as intersections of future and past directed light-cones, could be seen as correlates of perceptive fields [L92, L111] which in TGD are 4-D so that also memories could be seen as analogs of sensory perceptions. CD is analogous to a Big Bang followed by a Big crunch. The CDs form a fractal hierarchy.

   The visual field becomes more and more hyperbolic. What we would see is the projection of the patterns of $H_a^2 \subset H_a^3 \subset M_+^4$ to $E_t^2 \subset E_t^3 \subset M_+^4$, where a is cosmic time and t is the linear Minkowski time.

3. At the next step the 2-D patterns in H^3 are replaced by patterns in H^3 as hyperbolic analogous of curved surfaces in E^3 and one can say that the dimension of the visual field becomes 3.

4. In TGD Universe space-time surfaces are minimal surfaces [L113] and analogous to 4-D soap films spanned by frames appearing as singularities where minimal surface property and also the determinism of field equations fail so that the frames are space-time correlates as seats of non-determinism. The saddle property of minimal surface could explain the appearance of the "hyperbolic plants" which Emilsson lists as part of DMT experience.

Do we really see a hyperbolic world or does the visual perception reflect only the statistical geometry of the brain? The TGD proposal is that these two views reflect real space-time surfaces. One can of course argue that since conscious experience itself is associated with quantum jumps in the TGD framework so that the experience is about becoming rather than about being in the physical sense.

2. Algebraic complexity of the experience as a second parameter

The second parameter discussed in the talk was meant to characterize what was called valence as a measure for the "degree of bliss" of the experience. TGD counterpart would be algebraic complexity associated with the extension of rationals defined by the polynomial defining the space-time region. The value of $h_{eff}/h_0 = n$ as dimension of extension would serve as the parameter [L96, L97] For large values of n the situation becomes too complex to comprehend or remember and the bliss is lost.

In the TGD framework more complex systems can be engineered as functional composites of polynomials and this leads to the increase of h_{eff}. One can interpret this also as a construction of many-particle states with each polynomial, which represents a particle-like entity. When a fixed polynomial is iterated functionally, one obtains a fractal known as Julia set so that the connection with fractals is quite concrete [L100, L114, L115].

To sum up, the reports of Emilsson suggest a very concrete connection between DMT experience and TGD based views of space-time and number theoretical vision about quantum theory explaining dark matter as $h_{eff} = nh_0$ phases. DMT perception would be perceptions of both ordinary and dark matter simultaneously.

5.5.3 Possible implications for the interpretation of TGD

The proposed picture involving in an essential manner both H^3 and E^3 suggests some highly non-trivial implications concerning the physical interpretation of TGD.

H^3 is ideal for information storage and holography

The hyperbolic radial distance r_H in H^3 from origin is given by $r_H = aarsinh(r_E/a) \simeq alog(r_E/a)$, where r_E is the Euclidean distance in E^3. r_H depends logarithmically of r_E slowly. The area $S = 4\pi a^2 r^2$ of the hyperbolic sphere of radius u projected to Euclidean sphere with r increases as function of u as $S \simeq 4\pi a^2 exp(2u/a)$. One can imbed a tree graph (say) m ranches in the node much more effectively than in the Euclidean case. One can think of the tree graphs a simple model for a neural network consisting of layers such that n:th layer has m^n nodes for

If a given node requires fixed area ΔS, the solid angle $\Delta \Omega$ required by a node decreases as $1/r^2$ whereas in E^3 it remains constant, the number of these areas at sphere increases as $S/\Delta S = 4\pi exp(2u/a)/\Delta S$. In the Euclidean case it increases as $S/ = 4\pi r^2/\Delta S$. This means that the geometric information storage capacity of H^3 is exponentially larger. Therefore the idea that the 3 surfaces associated with H_a^3 could serve as information storage is very attractive.

H^3 and the origin of p-adic length scale hypothesis

p-Adic prime assignable to a region of the space-time surface is identified as the largests ramified prime associated with the polynomial defining the region of the space-time surface. p-Adic length scale hypothesis states that the physical preferred p-adic primes correspond to p-adic primes $p \simeq m^k$, where m is a small integer: $m = 2$ is the most important case.

I have proposed that there are two scales involved. The small p-adic length scale associated with m and the exponentially larger p-adic length scale proportional to $\sqrt{p}$. The origin of these scales has remained a mystery.

Could the small scales correspond to the radial scales r_H and large scales to radial scales r_E?

1. H_3 allows tessellations playing a key role in TGD framework and the size scale of the cell of the tessellation defines a natural length scale unit $\Delta r_H = aX$, which could define the small scale and scales would be expressible in terms of this unit.

2. In E^3 the natural scale would correspond to Euclidean lattices with constant cell size Δr_E. For $r_H = \Delta r_H$, $r_E = asinh(r_H/a) \simeq aexp(r_H/a)$ would give $r_E \simeq aexp(nX = am^{\Delta X/log(m)}$.

3. $r_E = L_p = \sqrt{p}R$ would give $\sqrt{p}R = am^{\Delta r_H log(a)/alog(m)}$. p-Adic length scale hypothesis $p \simeq m^k$ requires $X = klog(m)/2log(a/R)$.

   Note that there would be a logarithmic dependence of the p-adic length scale on the a, which would have an interpretation as a renormalization of the p-adic length- and mass scales.

5.6 Support for the magnetic densory canvas hypothesis

Magnetic sensory canvas hypothesis is certainly the craziest idea inspired by TGD inspired theory of consciousness. The effects of Lithium on brain function lend support for the notion of magnetic body. The effects of atmospheric and magnetospheric electromagnetic phenomena to conscious experience would also support the sensory canvas hypothesis. If sensory organs are the seats of primary sensory qualia, the possibility that atmospheric phenomena could induce extrasensory percepts is excluded. Sensory percepts based on back-projection mechanism might be however possible. Taos hum is a strange anomaly which might also relate to the magnetic body and dark matter at it.

5.6.1   Invisible magnetic fields as a support for the notion of monopole flux tube

Physicists studying a system consisting of a layered structure consisting of alternate superconducting and spin liquid layers have found evidence for what they call invisible magnetic fields. The popular article is published in Scitechdaily (`https://cutt.ly/XVmeOXj`) and tells about research carried out by Prof. Beena Kalisky and doctoral student Eylon Persky in Bar-Ilan University. The research article is published in Nature [D39] (`https://cutt.ly/wVme7pu`).

First some basic notions.

1. The notions of spin liquid and charge-spin separation are needed. Popular texts describe charge separation in a way completely incomprehensible for both layman and professional. Somehow the electron would split into two parts corresponding to its spin and charge. The non-popular definition is clear and understandable. Instead of a single electron, one considers a spin liquid as a many-electron system associated with a lattice-like structure formed by atoms. The neighboring electrons are paired. There are a very large number of possible pairings. In the ground state the spins of electrons of all pairs could be either opposite or parallel (magnetization). Pairing with a vanishing spin is favoured by Fermi statistics.

   If the opposite spins of a single pair become parallel and this state is delocalized, one can have a propagating spin wave without moving charge. If one electron pair is removed and this hole pair is delocalized ,one obtains a moving charge +2e without any motion of spin.

2. When a superconductor of type II is in an external magnetic field with a strength above critical value, the magnetic field penetrates to the superconductor as vortices. Inside these vortices the superconductivity is broken and electrons swirl around the magnetic field. This is how the magnetic flux quanta become visible.

   In the layered structures formed by atomic layers of spin liquid and superconductor, magnetic vortices are created spontaneously in the superconducting layers. In the Maxwellian world, magnetic fields would be created either by rotating currents or by magnetization requiring a lattice-like structure of parallel electron spins. In the recent case spontaneous magnetization should serve as a signature for the presence of these magnetic fields.

   Surprisingly, no magnetization was observed so that one can talk of "invisible" magnetic field.

   In the bilayered structure 4Hb-TaS$_2$, the superconductivity is anomalous in the sense that the critical temperature is 2.7 K whereas in bulk superconductor 2H-TaS$_2$ it is .7 K. There is also a breaking of time reversal symmetry closely related t the presence of the magnetic flux quanta. The magnetic flux quanta survive above critical temperature 2.7 K up to 3.6 K and their life time is very long as compared to the electronic time scales (12 minute scale is mentioned). Therefore one can talk of magnetic memory.

   The proposal is that a spin liquid state known as a chiral spin liquid is created and that the invisible magnetic field associated with the chiral spin liquid penetrates to the superconductor as flux quanta.

   Could TGD explain the invisible magnetic fields?

1. TGD predicts what I called monopole flux tubes, which have closed, rather than disk-like , 2-D cross sections and carry monopole flux requiring no current nor magnetization to generate it.

   This is possible only in the TGD space-time, which corresponds to a 4-surface in 8-D space $H = M^4 \times CP_2$, but not in Minkowski space or in general relativistic space-time in its standard form. The reason is that the topology of the space-time surface is non-trivial in all scales.

   The possibility of closed monopole flux tubes without magnetic monopoles, is one of the basic differences between TGD and Maxwell's theory and reflects the non-trivial homology of CP_2.

2. Monopole flux tubes solve the mystery of why there are magnetic fields in cosmic length scales and why the Earth's magnetic field B_E has not disappeared long ago by dissipation [L29].

3. Electromagnetic fields at frequencies in the EEG range corresponding to cyclotron frequencies have quantal looking effects on brains of mammalians at the level of both physiology and behavior. The photon energies involved are extremely low.

   In the TGD based quantum biology they can be understood in terms of cyclotron transitions for "dark" ions with a very large effective Planck constant $h_{eff} = nh_0$ in a magnetic field of .2 Gauss, which is about 2/5 of the nominal value .5 Gauss of the Earth's magnetic field B_D. The proposal is that B_E involves a monopole flux contribution about $2B_E/5$ [K60].

   The estimate for the invisible magnetic field was .1 Gauss so that the numbers fit nicely.

The findings suggest that the spin liquid phase atomic layer involves the monopole flux tubes assignable to the Earth's magnetic field and orthogonal to the layer. They would not be present in the superconducting layer but would penetrate from spin liquid to the superconductor.

5.6.2 Lithium And Brain

My friend Samppa told about positive effects of lithium on brain. I have proposed years ago that these effects could be explained by cyclotron frequency hypothesis and I decided to search for web about the recent situation. Lithium has been used for more than 50 years as a mood stabilizer in manic depression. During last years Lithium has been studied intensively and found that it can be used also in treatment of schizophrenia and many other brain disorders. The popular and somewhat hypeish article "Lithium promotes longevity-mood and love" at `http://tinyurl.com/ns9ksms` tells about various applications of lithium. Even statistical evidence that lithium reduces violent crime is represented.

Basic findings

To my view the importance of these apparently rather specific effect is that it lends support for the notion of magnetic body.

1. Lithium is found to increase the volume of grey matter (see the artcle "Lithium-induced increase in human brain grey matter" at `http://tinyurl.com/gu2s4ps`) and it is accumulated in white matter (axons) (see the article "Lithium in brain" at `http://tinyurl.com/zm9a4gm`). Lithium also enhances axonal growth and myelinination.

2. The higher concentration of lithium in drinking water is found to reduce mortality and suicide rate. It has been also found that higher lithium concentration increases the life span of bacteria (see `http://tinyurl.com/z73ayq4`).

3. Lithium might also help in Altzheimer's disease and other neurodegenerative diseases such as Parkinson's and Huntington's disease. Lithium is found to inhibit neuro-atoptosis (death of neurons). Lithium's neuroprotection may result from its inhibition of protein GSK3, which in turn prevents neuroatoptosis regulating survival and differentiation.

4. Lithium is found to increase neurogenesis helping the healing of brain injuries (see artcle "Inactivation of Glycogen Synthase Kinase 3 Promotes Axonal Growth and Recovery in the CNS" at `http://tinyurl.com/hlfbkvz`). Lithium has also positive effect on memory. Lithium affects various signalling proteins and pathways. Indeed, lithium has been claimed to serve as "brain food" (see `http://tinyurl.com/zhe5ckf`).

5. Disruption in the blood-brain barrier is proposed to be a missing link between brain and body flammation in bipolar disorder [J94] (see `http://tinyurl.com/ya9tqzj8`). According to the abstract of the article:

   The blood-brain barrier (BBB) regulates the transport of micro- and macromolecules between the peripheral blood and the central nervous system (CNS) in order to maintain optimal levels of essential nutrients and neurotransmitters in the brain. In addition, the BBB plays a critical role protecting the CNS against neurotoxins. There has been growing evidence that BBB disruption is associated with brain inflammatory conditions such as Alzheimer's disease and multiple sclerosis. Considering the increasing role of inflammation and oxidative stress

in the pathophysiology of bipolar disorder (BD), here we propose a novel model wherein tran-
sient or persistent disruption of BBB integrity is associated with decreased CNS protection
and increased permeability of proinflammatory (e.g., cytokines, reactive oxygen species) sub-
stances from the peripheral blood into the brain. These events would trigger the activation
of microglial cells and promote localized damage to oligodendrocytes and the myelin sheath,
ultimately compromising myelination and the integrity of neural circuits. The potential im-
plications for research in this area and directions for future studies are discussed.

The mechanism of lithium-brain interaction is still unknown: mechanisms like altered mitochondrial function, inflammation, dysregulated dopaminegic/glutamatergic systems have been proposed. It is said that lithium helps to cure multisystem disorder rather than disease (reader can try to figure out what this might mean!). In any case, the effect of lithium seems to be on gene expression and it would seem that lithium only makes possible natural healing mechanisms to operate rather than providing single healing mechanism.

TGD view about Lithium's role

In TGD framework organism-environment pair of standard biology is replaced with the triplet magnetic body - organism -environment [K88, K87, K86]. Magnetic body uses biological body as sensory receptor and motor instrument. This suggests that the re-establishment of communications of brain with some level of the magnetic body is how lithium causes its positive effects. The disorders caused by the lack Lithium and other biologically important ions would be something totally new from the perspective of standard neuroscience. The standard idea that some kind of neuronal receptors or some information molecules are underpresented or over-represented would not be enough. Magnetic body would take care of healing in much more effective manner than more or less random tinkering of bio-molecular concentrations.

1. The basic hypothesis is that communications between biological body and magnetic body correspond to sending sensory input from the cell membrane to magnetic body as generalized Josephson radiation and receiving control command from magnetic body controlling gene expression as cyclotron radiation [K89, K90, K44].

   The control commands from magnetic body would rely on signals having carrier waves with cyclotron frequencies associated with dark variants of biologically important ions and assignable to dark magnetic bodies forming an onionlike scale hierarchy with sizes of order cyclotron frequency in endogenous magnetic field $B = 2B_E/5$, where $B_E = .5$ Gauss is the nominal value of the Earth's magnetic field. The size scale assignable to 10 Hz frequency would be of order Earth size.

   The sensory communications to magnetic body from cell membrane based on generalized Josephson frequencies associated with cell membrane regarded as generalized Josephson junction. The frequencies of radiated dark photons would be differences of cyclotron frequencies at the two sides of the junction plus relatively small contribution corresponding to the ordinary Josephson frequency determined by the membrane potential. Nerve pulse activity would thus induce frequency modulations of the carrier wave: kind of whale's song (or human speech) would be in question. Also amplitude modulation and even modulation of the polarization of radiation can be considered.

   The value of Planck constant is large and EEG frequencies correspond to energies in the energy range of biophotons assumed to result in the transformation of dark photons to ordinary ones visible and UV photons. These energies correspond to excitation energies of biomolecules so that magnetic body could induce chemical reactions.

   The gravitational Planck constant $\hbar_{gr} = GMm/v_0$ (here M and m denote masses connected by magnetic flux tubes carrying dark gravitons and $v_0/c < 1$ defines a velocity parameter - some natural velocity in the system) introduced originally by Nottale [E2] is identified with the effective Planck constant $h_{eff} = n \times h$ emerging in TGD framework from the fractal hierarchy of isomorphic sub-algebras of super-conformal algebras of various kinds (generalizations of ordinary conformal algebras) serving as symmetries of quantum TGD [K37, K38, K39, K40].

If M corresponds to large central mass and m to a mass of charged particle (elementary particle, ion, molecular ion,..), one obtains that cyclotron energies proportional to h_{eff}/m do not depend on mass number at all so that cyclotron energy spectrum is universal (and corresponds to that of bio-photons in visible and UV where also molecular transition energies are). The additional prediction is that each charged dark particle is at its "personal" dark magnetic flux tube. Instead of being a random chemical soup, dark living matter is highly organized, somewhat like library containing each book at its own self! It is difficult to exaggerate the importances of this implication.

2. The most important biologically important ions include H^+, Li^+, Na^+, Cl^-, K^+, Ca^{++}, Mg^{++}. If some of these ions are absent, the communications to the corresponding layer of the magnetic are not possible and this part of magnetic body cannot control the corresponding parts of brain. The generation of these ions could be based on charge separation causing also the formation of exclusion zones (EZs) of Pollack [L23] as protons are transformed to dark protons at dark flux tubes outside EZ.

   It is known that lithium ions accompanying lithium carbonate Li_2CO_3 dose intefere with ion transport processes (sodium pump) pumping Na^+ ions from cell interior (see `http://tinyurl.com/y9u4uorr`). This suggests that also Li ions give rise to dark generalized Josephson currents through the cell membrane.

3. Electron corresponds to 6×10^5 Hz, proton to 300 Hz, and lithium cyclotron frequency is 50 Hz and could be assigned to the limbic brain. Mg^{++} corresponds to 26 Hz, Ca^{++} to 15 Hz, Na^+ to 13 Hz, Cl^- to 8.5 Hz, K^+ to 7.5 Hz, etc... Iron and Cobolt would have cyclotron frequencies near 10 Hz of alpha band. The cyclotron frequencies for ^{6}Li and ^{7}Li are 50 Hz and 43 Hz.

   Also higher harmonics of cyclotron frequencies are present and I have proposed that the magnetic field strength has spectrum, which corresponds apart from scaling to the frequency spectrum of biophotons, so that this picture is oversimplified. For instance, in retina 80 Hz frequency appears and would require stronger magnetic field unless it corresponds to higher harmonic.

4. Magnetic fields oscillating at 50 Hz frequency are known to have biological effects [K89]. The size of the corresponding magnetic body part would be obtained from the wavelength $\lambda = 2\pi R$ (R denotes the radius of Earth) of the lowest Schumann frequency 7.8 Hz as $L = (7.8/50) \times R = .98 \times R$. This suggests that dark magnetic flux tubes assignable with Earth are involved: not however that the field strength is $2B_E/5$.

   Quite recently (towards end of 2016) I learned that in 1986, scientists at Cornell University examined the effects of the two isotopes of Lithium on the behavior of rats (see `http://tinyurl.com/zyy3b4l`). Pregnant rats were separated into three groups: One group was given lithium-7, one group was given the isotope lithium-6, and the third served as the control group. Once the pups were born, the mother rats that received lithium-6 showed much stronger maternal behaviors, such as grooming, nursing and nest-building, than the rats in either the lithium-7 or control groups.

   The naïve guess is that EEG amplitude at 50 Hz is enhanced thanks to ^{6}Li dose. It is found that the increase of lithium carbonate level for patients increases EEG delta and theta intensities and slow down alpha frequency (see `http://tinyurl.com/z88okg7`): unfortunately there is no mention about 50 Hz. The simplest interpretation is that improved communications at 50 Hz induce healing and indirectly improve communications also at lower frequencies. The slow down of alpha frequency remains to be understood. The precise values of cyclotron frequencies are controlled by magnetic body by varying flux tube thickness (flux quantization and conservation implies correlation of field strength with the thickness of the flux tube). Typical variation is about 10 per cent.

5. A naïve dimensional guess is that the size scale of the part of the magnetic body corresponding to particular part of brain is proportional to its size. The naïve scaling argument would suggests that lithium scale is few centimeters. One must of course take this kind of estimates with extreme caution. The most primitive parts of CNS such as spinal chord and brain stem

would correspond to highest frequencies in EEG and also above it, and the most advanced parts such as cortex or its sub-structures to the lowest frequencies such as at 10 Hz alpha frequency: lower frequencies would not correlate directly with our conscious experience but could correspond to large structures giving rise to collective levels of consciousness.

To sum up, lithium could help by re-establishing the connection to the lithium part of the magnetic body so that it could fix the part of brain involved. This would take place by control commands controlling gene expression.

50 Hz electric oscillation wakes up brain

Thanks for Ashton Martin for very interesting link (`http://tinyurl.com/wfbooaq`) related to neuroscience. The popular article tells about the work of Michelle Redinbaugh *et al* [J62] (`http://tinyurl.com/uwfvatr`). The researchers have conducted experiment on monkeys in anaesthesia and conclude that the activation of central lateral thalamus by 50 Hz electric oscillations may enable consciousness. Activation of the central lateral thalamus and deep layers of the cerebral cortex drives pathways in the brain that carry information between the parietal and frontal lobe in the brain, the study suggests.

From TGD point view the conclusion is too far fetched and reflects the naïve "consciousness-module" thinking. The fining is however very interesting from the view point of TGD inspired theory of consciousness and quantum biology.

1. The wakeup from anaesthesia happened using 50 Hz electric stimulation of central lateral thalamus.

2. In TGD framework magnetic body (MB) carries dark matter as phases of ordinary matter with effective Planck constant $h_{eff} = n \times h_0$, which can be very large. n serves as a kind of IQ and MB serves as a master using biological body (BB) - in particular brain - as slave. EEG and it scale variants serve as a tool for communication to and control by MB. EEG photons are dark with large h_{eff} and can transform to bio-photons in visible and UV energy range and thus affect molecular transitions.

3. MB has layered structure with cyclotron frequencies of biologically important ions associated with the control by MB in "endogenous" magnetic field $B_{end} = .2$ Gauss identifiable as monopole flux part of Earth's magnetic field with nominal value $B_E = .5$ Gauss. B_{end} explains the findings of Blackman and others about the effects of ELF radiation on brain and also why EEG correlates with consciousness and brain state. Without MB sending of EEG radiation to outer space would be horrible waste of energy resources.

4. For ^{7}Li the cyclotron frequency for B_{end} is 50 Hz. Litium is known to have healing effect on depression and heal axonal infection. Depression and other problems could be due to the lack of communications to MB or control by MB. This would be due to a lack of magnetic flux tubes containing cyclotron B-E condensate of biologically important ions. MB could not take care of BB.

5. Interestingly, the rate of lightnings in Earth's atmosphere is 50 Hz (`http://tinyurl.com/rb2l737`) and corresponds to a very strong peak in the em resonance spectrum of Earth including also Schumann resonances at 7.8, 14, 20, 26, 33, 39, 45 and 59 Hz (`http://tinyurl.com/r2dge5y`). TGD inspired theory of consciousness predicting self hierarchy and that the MB of Earth - Magnetic Mother Gaia - is also a conscious entity, suggests a connection.

6. The finding suggests that some layer of MB of thalamus region producing dark cyclotron radiation at cyclotron frequency of Li manages to wake up this brain region in presence of irradiation. How?

   (a) The model of water memory based on MB and water as a poly-phase involving dark magnetic flux tubes with $h_{eff} = n \times h_0$ suggests that 50 Hz frequency generates in water flux tubes with cyclotron frequency of 50 Hz which act as receiving and sending antennas.

(b) Water would detect this frequency by tuning the thickness of the flux tubes to tune cyclotron frequency to 50 Hz: this is possible for monopole flux tubes not allowed by Maxwellian ED: flux is conserved and changing the thickness changes the cyclotron frequency. The antennas can send and receive 50 Hz radiation. The 50 Hz antennae generated by oscillation em field would be able to receive the cyclotron radiation from MB and wake up.

(c) The flux tubes can also tune to the cyclotron frequencies associated with the MBs of invader molecules and this would make possible to generate "fake" molecules as MBs of water clusters. This would explain water memory, and give rise to basic recognition mechanism of immune system. Also homeopathy would be real effect and be based on the build-up of "fake" variants of molecules as flux tube antennae tuned to cyclotron frequency spectrum of MB of molecule. This requires metabolic energy feed to increase the value of h_{eff} at magnetic flux tubes and the agitation of water would provide this energy.

Magnetic sensory canvas hypothesis is certainly the craziest idea inspired by TGD inspired theory of consciousness. The effects of atmospheric and magnetospheric electromagnetic phenomena to conscious experience would support the sensory canvas hypothesis. If sensory organs are the seats of primary sensory qualia, the possibility that atmospheric phenomena could induce extrasensory percepts is excluded. Sensory percepts based on back-projection mechanism might be however possible.

5.6.3 Atmospheric And Ionospheric Phenomena And Sensory Canvas Hypothesis

The sounds claimed to be generated by auroras and meteors and the correlation of UFO reports and ET experiences with tectonic activity provide some clues in the attempt to develop magnetic sensory canvas hypothesis. Also various anomalous visual percepts and OBE experiences provide challenges for the model.

The sounds generated by auroras

There are claims that auroras generate audible sounds [F7] (for the quantum model of auroras see [K26]). These sounds have not been detected by acoustic means. Of course, it might be only a matter of time when this is done.

A particular example of microwave hearing [I63] could be in question. The microwave MEs generated in auroras could propagate like massless particles along ELF MEs to brain, and induce cortical perturbations modulated by ELF frequencies serving as modulating frequencies and determining the pitch of the sounds heard. The perturbations would be analogous to electric stimulation of cortex inducing sensory percepts by back-projection mechanism. The cortical perturbations would generate auditory sensations by the back-projection mechanism. Higher Schumann resonances are in the audible range and could also be mediated along the flux tubes from the magnetic body or magnetosphere to brain and induce audible sounds by the back-projection mechanism.

The TGD based model of hearing relies heavily on classical Z^0 fields and auditory canvas could be actually Z^0 magnetic. Since all classical fields are expressible in terms of CP_2 coordinates, magnetic storms are expected to be accompanied by their Z^0 magnetic counterparts.

The sounds generated by meteors

so some further evidence for the sensory canvas hypothesis. Since 16th century it is known that also meteors produce audible sounds. What is mysterious that there is no time lag due to the propagation through the atmosphere. The explanation is that it is very low frequency em waves which propagate to Earth and generate sounds by interacting with the objects at the surface of Earth. Joined by the International Leonid Watch - Croatia (ILWC) project, a group of scientists presented the first instrumental detection of elusive electrophonic meteor sounds. In November 1998, the researchers from the Croatian Physical Society and the University of Kentucky organized

an expedition to Mongolia to observe the anticipated Leonid meteor shower and shed some light on the phenomenon [F4].

The complete data analysis revealed two electrophonic sounds that provided several important clues about the nature of this longstanding astronomical mystery. It became clear that sounds were created when the meteors were crossing night-time ionosphere (the heights involved are in 85-110 km). The electrophonic sounds seem to be produced inside the measuring apparatus suggesting that electromagnetic energy is transformed to sound at this stage. The existing theories cannot however completely explain the phenomenon. The energy of the meteor does not seem to be high enough to invoke the electric fields needed to explain the electronically recorded sounds: only one percent of the electric energy is estimated to be transformable to acoustic form but the required conversion ratio seems to be 100 percent and perhaps even higher than this. The frequencies are much lower than the expected range 20-20.000 Hz range for sferics, which by the way is the range of audible sounds, not an accident in TGD universe. The fundamental frequencies are in the region 37-44 Hz but are consistent with the psychophysical correlate of the sound (deep "pop").

Magnetic mirrors as carriers of the electromagnetic perturbations might allow a better understanding of the phenomenon. What is intriguing that the frequencies are in the range 37-44 Hz: this frequency range is the same as associated with the average value of the thalamocortical resonance frequency of 40 Hz. This frequency range should be associated with the sensory representations on the magnetic canvas. It is known that sounds near 40 Hz induce strong effect in EEG. The first hypothesis is that the interaction of these em fields with brain generates the perceived sound. On the other hand, in TGD framework these sounds are represented ultimately in the magnetic sensory canvas: thus the intriguing possibility is that the consciously perceived sounds are in fact generated by the direct perturbations of the magnetic or Z^0 magnetic auditory canvas and are genuine ESP effects.

The recorded electrophonic sounds could be induced by electromagnetic perturbations propagating along magnetic mirrors at multiples of the fundamental frequency $f = c/L$ determined by the length L of the magnetic mirror and the mirrors might not only channel the electromagnetic energy very effectively but even act as resonators amplifying the em fields. In fact, in one of the models analyzed in [F4], the electric fields on the surface of Earth must have the same strength as the electric fields created by the meteor in its immediate vicinity in order to explain the data! If the electric fields are channelled along the magnetic mirrors associated with the magnetic sensory canvases to the surface of Earth, the frequency spectrum is automatically in the "thalamocortical" range instead of the expected $20 - 20.000$ Hz range for the sferics and one can understand why only few meteors generate electrophonic sounds. Notice that magnetic mirrors of length shorter than Earth's circumference would give rise to higher resonance frequencies than Schumann frequencies: the required length of the mirror would be roughly 1.26 Earth radii for 40 Hz frequency.

One can imagine tests for the sensory canvas hypothesis and for the possible ESP character of the heard sound (in the sense that the heard sound is induced cortically rather than received from environment).

1. One could construct acoustic amplifier in 37-44 Hz range so that human perceiver could hear both the direct ESP sound and the sound generated by the amplifier. This would mean hearing two "pops", such that the interval between them is determined by the time used to the sensory processing and propagation of the sound from the external source. In fact, in the introduction of [F4] it is mentioned that "many witnesses heard sounds even before they heard the noise inside the house". Assuming that the sounds are both heard and electronically detected, a neurophysiological model for the time lapse from the sensory input to the conscious percept would allow to test whether the consciously perceived sounds can have non-ESP origin. If the lag is too small, ESP interpretation is supported.

2. The human perceiver could use ear plugs. If "pop" is heard also in this case, the only possible interpretation (excluding fraud) is that the sounds are generated either by the neuronal activity stimulated by the interaction of the ELF em perturbation with brain, that the sound is generated in body as physiophonic sound [I93], or that a genuine ESP is in question. The phenomenon of physiophonic sound discovered by Antonio Meucci in 1842 means the amplification of external sounds or electromagnetic signals by musculature and their feed

directly to the neural circuits (ears could be closed) and is a rather convincing explanation for the heard sounds. The possibility of fraud could be eliminated by excluding the possibility of the direct visual perception of the meteor and finding whether the heard sounds coincide with the electronically detected sounds.

UFOs, ETs and magnetic perturbations

Persinger has proposed a model explaining the encounters of extraterrestrials as hallucinations caused by the perturbations of Earth's magnetic field induced by the liberation of the tectonic energy at the lines of tectonic activity [J103]. The model is based on well-established statistics about the effects of the perturbations of Earth's magnetic field on consciousness collected in mental hospitals. The lines of the tectonic activity are also accompanied by well established luminous phenomena which suggests that the model could be naturally combined with the explanation of UFOs as this kind of luminous phenomena.

The most obvious guess is that a beam of visible light or ions emerges from the region where the tectonic energy is liberated. If this beam somehow produces a localized ball lightning type phenomenon it could be interpreted as UFO. If the direction of the beam varies randomly the resulting UFO performs random butterfly like motion and in principle the velocity of motion can be super-luminal since a signal velocity is not in question. The motion would resemble that of a flicker's light spot in a roof. Many UFO candidates have indeed found to move in this manner and this is quite a challenge in the attempts to understand the technology used.

1. Why a light spot rather than beam of light is observed?

The challenge is to explain why a localized pseudo UFO rather than a beam of light is observed.

1. One could consider the possibility that a radial spray of electric flux emanates from the site of the tectonic activity and electrons accelerate in this field until they gain the energy needed to ionize the molecules of the atmosphere and produce visible light. The analog of vacuum discharge would be in question. The problem is that the drifting velocity is achieved very rapidly so that the model works only if the density of molecules of the atmosphere decreases sufficiently fast as function of height. This is not the case.

2. Suppose that the spot of tectonic activity emits dark microwave photons including frequencies $f > 5$ GHz. In this case visible light could result via the de-coherence of the dark microwave photons to ordinary photons. The fraction of ordinary visible photons in the beam would behave as $1 - exp(-h/h_0)$ and at some critical height the beam would become visible as the visible photons scatter from the molecules of atmosphere.

3. Pseudo UFO could be a kind of a mini aurora produced by exactly the same mechanism as auroras. Similar mechanism could apply also to ball lightnings and other exotic luminous phenomena. The super-conducting magnetic flux tubes associated with the stream of magnetic flux assumed to emanate from the site of tectonic energy liberation would intersect with the magnetic flux tubes of Earth's magnetic field (or those emerging from the brain or body of the perceiver of ETs). This would lead to a reconnection process in which magnetic flux tubes having a local U-shape are generated. The inertia of the super-conducting ions (perhaps protons and electrons) would induce the leakage of the ions to the non-super-conducting atmospheric space-time sheet. This in turn would lead to a further ionization and the molecular electronic transitions would generate the visible light as in the case of auroras. Also electric fields could be involved as in the case of auroras. U-shaped structures would occur at definite height. By measuring the local electromagnetic fields one could perhaps test whether the orbit of the pseudo UFO correlates with the variation of the hypothesized stream of magnetic flux emerging from the site of the tectonic activity. The pseudo-UFO character could be tested by finding what kind of radar echoes the luminous region generates (if any).

2. What about ET reports?

The aurora mechanism could explain also the hallucinations as real encounters with other selves of the predicted self hierarchy rather than ETs. The tectonic activity could cause a similar perturbation of the personal sensory canvas and perhaps its temporal fusion with other sensory canvases, perhaps even with higher multi-brained sensory canvases possibly present. This would obviously induce genuine ESPs. The generalized motor response coming from the sensory canvas would be also involved but primary percept would occur before it. Brain would probably do its best to interpret the situation using concepts provided by the cultural background. Angels, spirits, demons, ETs, etc.. would be various narratives for the same phenomenon.

Also Schumann resonances are excited during tectonic activity and could correlate strongly with the experiences about encounters of ETs: this explanation is consistent also with option b). Similar mechanism might be behind hypnagogic experiences occurring at the boundary between wake and sleep. EEG is dominated by frequencies near the lowest Schumann frequency 7.8 Hz during hypnagogy and this might mean that the entanglement with other sensory canvases occurs with an enhanced probability.

Krishnamurti has told very movingly about experiences of literally being another one. Perhaps also other identification experiences, such as shamanic identification with animals, rely on the same mechanism. Also I have had strange hypnagogic experiences of being a totally different person for a moment. This picture would suggest that magnetic transition frequencies associated with the flux tubes of the magnetic sensory canvas emanating more or less vertically from the head code for the personal content of consciousness whereas Schumann frequencies relate with the transpersonal contribution to consciousness possibly present always and giving rise to a third person bird's eye of view about own person and amplified during hypnagogic experiences or by strong perturbations of Earth's magnetic field.

Anomalous visual percepts and sensory canvas hypothesis

Sensory canvas hypothesis means that at the level of magnetic body we see using ELF– rather than visible light. Of course, if primary sensory qualia are at the level of sensory receptors, this seeing has the character of imagination. Even in this case brain could use back-projection to the sensory receptors assign sensory qualia with the imagination like perception. This would occur during dreaming and what is regarded as hallucinations.

The model of EEG [K44] however leads to the conclusion that the Josephson radiation from cell membrane corresponds to dark photons with EEG frequencies and bio-photon energies so that they can transform to bunches of EEG photons or to bio-photons with ordinary value of Planck constant. This model predicts correctly the frequencies of maximal sensitivity for the four kinds of photoreceptors and a good guess is that this radiation could explain large number of various anomalies in which low frequency radiation has biological effects.

One can also consider the possibility of "vision" as a sensory experience of the magnetic body based solely on the ELF input from brain and body having no correlate with the visible light entering into the retina or even with neural activity. The de-coherence of (for instance) dark ELF photons with frequencies above alpha band level of the dark matter hierarchy to ordinary visible photons could be responsible for this vision.

Even genuinely three-dimensional vision in which own body is seen as it would be seen by the external world suggests itself. The dropping of ions from the atomic space-time sheets to the magnetic flux tubes so that they end up to high n cyclotron states decaying via the emission of photons at frequencies which are harmonics of the cyclotron frequency would generate the projector MEs needed for the sensory representation of the physical body or part of it as seen by the environment. In many-sheeted space-time particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries of space-time sheet of a given system. Also p-adic phase transition increasing the size of the space-time sheet could take place and the liberated energy would correspond to the reduction of zero point kinetic energy. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant h_{eff} so that cyclotron energy would be liberated.

There is some evidence for this kind of anomalous vision.

1. Yogis have reported altered states of consciousness in which they see their own body three-dimensionally, that is simultaneously from all directions. This might have interpretation as

ELF vision involving a feedback from magnetic sensory canvas to brain to "qualiafy" the percept. An alternative interpretation is that the visual experience is visual experience of some other self which is shared by quantum entanglement.

2. Becker tells in his book "Cross currents" [J113] about a young cancer patient who told that he can see the interior of his own body. The patient could also locate the remnant of the tumor correctly. If sensory receptors are necessary for visual qualia, the needed data must be received from somewhere by brain, and be projected to the retinas like during dreaming. The simplest option is that body parts can in some sense "see" each other. In particular, brain can "see" body parts (note that bacteria possess a primitive IR vision based on microtubules). Bio-holography provides support for the body as a hologram. For instance, an electric stimulation of ear during Kirlian imaging of a finger tip creates a Kirlian photo from which it is possible to abstract a hologram of ear (see [I139] and [K53]). One can also imagine that magnetic body "sees" and the mechanism is the transformation of dark EEG photons to visible photons.

3. Also the OBE experiences, for instance those associated with NDEs, could have an analogous interpretation. The sensory input from eyes would be absent but brain would give feedback to visual receptors to "qualiafy" the input which it might receive from other levels of self hierarchy. If even the input from neural activity is absent during NDEs so that the visual experience should be determined by the background ELF component emanating from the brain and body. The third person perspective associated with OBEs might be always present but be masked by the strong sensory input or by the absence of feedback to visual receptors. It is possible to have experiences about contact with deceased by a therapy based on rhythmic eye movements [J21, J73]. The function of eye movements might be to establish a feedback to certain brain regions serving as receivers of input from magnetic bodies of deceased or from magnetosphere. I have developed a detailed model for various kind OBE experiences in [K110].

4. I have proposed thousand and one explanations for the beautiful flow visible when I close my eyes in a calm state of mind. During my "great experience" this background flow was accompanied by extremely vivid visual hallucinations. An additional item to the long list of explanations is following. The information characterizing the flow enters from or via brain to the visual receptors and is in this manner "qualiafied".

What has been said about magnetospheric third person aspect applies also to other senses. Interestingly, I often wake-up partially and realize that I hear my own snoring as an outsider (quite a dramatic experience!). Sometimes I have had an experience which might be interpreted by saying that the hearing in the first perspective is superposed with the hearing in the third person perspective. The third person hearing has a time lag so that a kind of double breathing results.

5.6.4 Taos hum

Taos hum (see this) is an experimentally well-established anomalous phenomenon which has escaped rational explanations (in the article [I93] a thorough review about nocturnal taos hum is given and the following representation relies on this article). Very concisely, taos hum seems is apparently a subjective experience without identifiable objective counterpart and could thus provide an application for the sensory canvas hypothesis.

The TGD based model for EEG [K44] is based on dark Josephson radiation generated by cell membrane Josephson junctions in the energy range of visible and UV light and covering a wide frequency range. The model explains bio-photons and EEG photons as manifestations of one and same thing. Taos hum might be perhaps understood in terms of this kind of Josephson radiation at microwave frequencies generated by living matter during night-time and possibly providing some organisms with an active vision. The emission of negative energy dark photons could also make it possible for plants to suck metabolic energy from environment in the absence of solar radiation.

Also other interpretations might be considered and the most recet idea suggests a connection with quantum gravitation,

Basic facts

Taos hum is perceived in and around Taos, New Mexico but similar phenomena are experienced also in Northern America and Northern Europe. The hum is mostly heard during night time. Most people experience the hum as irritating and it causes nocturnal disturbances. From the tests based on psychophysical matching the frequency range of the hum has been deduced to be 40-80 Hz and whereas amplitude is around 60 dB. The hum is a regional phenomenon. The hum does not usually appear between sunrise and sunset. The pitch and intensity of the hum varies inside house and finds the largest magnifications on lower floors. Rooms modify the hum by adding distinctive harmonics to it. The pitch of the hum changes when one moves from outer wall to the interior rooms. Hallways and small alcoves raise the pitch considerably. The wavelengths involved vary between 3.9-7.8 meters for 40-80 Hz frequency range which suggests that resonance effects could be involved. It has been however impossible to identify any acoustic origin for the phenomenon. The presence of effectively acoustic effects suggests that gigantic amplification by the physical (and em!) body of the patient is involved.

Hum can involve also an experience about whirling or roaring wind, kind of vortex although nothing moves around, and coming from all directions. Also a strange amplification of distant sounds can be experienced. White light in the horizon in the direction where hum comes from can be also perceived. Experiences analogous to hum have been reported also in past, even in antique ("Aeolian wind"), but nowadays the number of victims of the hum has increased, which suggests a connection with the emergence of electronics and computers. The direction which hum is experienced to come from seems to be random.

The hum can be accompanied by irritating tactile sensations and neuralgic pain. The unfortunate individual who suffers of extreme HUM disturbances, seems to be controlled by very fundamental and autonomic response-reflexes when in its grips. Such sufferers may behave in semiconscious modes, modelling behavioral patterns seen only in animals. Typically the victim tends to get underground believing that this allows to get him rid of the hum. The victims of hum indeed tend to wake up with the realization that they have very strong and painful muscle tenure.

An important hint as regards to mechanism of hum is the fact that the temporal patterns of the shortwave radio static detectable by shortwave receivers correlate strongly with those associated with the hum. It is also known that the static has a biological origin: the warbling sounds characterizing the static resemble those produced by plants and galvanic skin response sensors. And most importantly, the statics is present during night time.

All attempts to detect the hum instrumentally and to identify its source have failed. This has inspired various kinds of conspiracy theories about the nature of the phenomenon, for instance, the proposal the strong ELF power feed by submarine radars alone could explain the phenomenon.

Phenomena possibly related to taos hum

It is appropriate to discuss first some phenomena possibly related to the taos hum before considering the model for the phenomenon itself.

1. Microwave hearing

During the collaboration with Joaquim Fernandez related to the construction of a a model for so called Fatima miracle [H2] I learned about the phenomenon of microwave hearing [I63] in which microwaves generate an audible sensation. There is evidence that microwave hearing does not involve ears as receivers of the primary signal [I39] and that the sensation of hearing could result as back-projection from cortex to ears.

This, and the correlation with microwave static suggest that taos hum could be a particular case of microwave hearing. The model of sensory representations implies that brain acts as a sending microwave antenna: a natural implication is that brain can act also as a receiving microwave antenna. The size of the brain hemisphere corresponds to a microwave frequency of order 3 GHz and smaller structures inside brain correspond to higher radio frequencies. If primary sensory organs are the seats of the sensory qualia and that back-projections cannot induce physical pain, the presence of the painful tactile sensations means that microwaves must interact also with the sensory receptors at the skin.

Why taos hum? Could animals use microwaves for "seeing" in absence of sunlight? But for

what purpose plants would use microwaves? Could organisms send negative energy $h_{eff} = n \times h$ [K37, K38, K39, K40] microwaves to environment and suck metabolic energy quanta with energy around .5 eV in this manner? Remote metabolism! Or maybe time reversed photosynthesis in dark! Biophotons indeed have energy spectrum in visible and UV as also sunlight does. This would require non-standard value of Planck constant.

This hypothesis would explain why the microwaves causing taos hum not hum are not observed directly. And if something is sucking metabolic energy from you, it is would be rather natural to experience very unpleasant feelings and try to find a place to hide as many sufferers of taos hum try to do!

2. Physiophonic effect

Physiophonic effect is a phenomenon accidentally discovered by Antonio Meucci in 1842, in which vocal signals are electrically transmitted directly into the neurology of listeners [I93]. Physiophonic sound can be often amplified to an enormous volume. A possible interpretation is as externally stimulated internal sound but one can of course wonder whether the transduction to sound is necessary.

Since the body (especially collagen network) is liquid crystal allowing piezoelectric effect in which mechanical vibrations are transformed to electric signal, external sounds could be transformed to electric fields. On course, LC property implies that also genuine sound is generated so that both ELF em fields and ELF sounds can act as amplified signals. One can ask whether strong back-projection to the ears is generated so that sound percept results. This would imply oto-acoustic sounds directly detectable by microphones not found in the case of taos hum.

3. Microwave static and taos hum

It is known that the temporal patterns of the shortwave static detectable by shortwave receivers correlate strongly with those associated with the hum. It is also known that the static has a biological origin: the warbling sounds characterizing the static resemble those produced by plants and galvanic skin response sensors. And most importantly, the fact that the static is present during night time would explain why hum is experienced at night time.

Possible ingredients for the model for taos hum

The facts about the role of the musculature, shortwave radio noise, and the role of acoustic environment combined with the model of microwave hearing based on the notion of dark photons [K57] pose strong constraints on the model of taos hum.

Taos hum as sensitivity to alien control commands

Magnetic bodies control biological body by sending control commands to brain and body where they are transformed to nerve pulse patterns and various physiological waves. Also the lower levels of self hierarchy should control the respective levels of the hierarchy, in particular muscle cells, in a similar manner. In the case of hum patient the normal control signal could be replaced by a control signal from some external biological source, say plants, and would be responsible for the muscular vibrations amplified to the hum. In the worst situation the behavior of hum patients reduces to simple reflex actions: these reflex actions would be initiated by fake control signals.

The fact that the taos hum begins after the sunset would conform with the interpretation as sucking of metabolic energy with energy quanta in visible and UV range. The loss of metabolic energy could explain why the experiences of patients are so unpleasant. Since motor action is based on negative energy signals affecting directly neuronal membranes by the same mechanisms as ordinary motor actions the signals would also induce reflex actions.

The situation would be due to the failure of the em (or rather, electro-weak) immune system of the patient. In order to understand what is involved a brief discussion of model of motor control based on charge entanglement induced by W MEs is necessary: a detailed model is discussed in [K53, K57].

1. The exotic ionization of dark matter induced by W MEs generates dark plasma oscillations inducing electric fields which by many-sheeted variant of the Faraday law induce electric fields also at the space-time sheets where ordinary matter resides. Various ionic waves, in

particular Ca^{2+} waves and nerve pulse are examples of the physiological responses resulting in this manner.

2. Dark plasma frequency corresponds to a microwave photon with energy above the thermal threshold and the system must be able to provide dark photons with this energy to generate plasma oscillation patterns serving as control commands.

The electro-weak immune system could fail in the following manner.

1. In the healthy situation em immune system takes care the body is tuned to the personal dark plasma frequencies and does not respond to control commands from alien magnetic bodies associated with say plants.

2. In an un-healthy situation persons plasma oscillation frequencies are tuned to some frequencies in the microwave static and microwave static provides the energy needed to generate plasma wave patterns and thus to realize control commands from the alien magnetic bodies. The plasmoids would induce microwave hearing and generalized motor actions at cellular level exhausting the personal metabolic sources and leading to the painful experiences and fatigue.

4. Taos hum and microwave hearing

The identification of the audible sensation associated with taos hum is in terms of microwave hearing explains the failure of the attempts to identify the source for taos hum. Amplitude modulation by ELF frequencies naturally associated with motor control would give rise to sensation of sound.

Concerning the model for microwave hearing, a good guideline is that the effect is expected to be possible as quantum effect only if the energies of the microwave photons are above the thermal threshold. This would require dark microwave photons for which 5 GHz photons have energy above thermal threshold (6 cm wavelength). Same applies to other effects caused by dark microwave photons.

Microwave hearing itself would rely on hearing of dark microwave photons at visible and UV frequencies. These dark microwave photons could accompany the microwave signal automatically or could be generated by cells via a phase transition increasing the value of Planck constant.

5. Taos hum and microwave seeing

The de-coherence of microwave photons to ordinary photons would produce the biological effects. This could explain also the reported perception of white light as resulting from the de-coherence of the microwave photons at the upper end of the spectrum: 1 mm microwave wavelength would correspond to 2.5 eV photon energy.

The de-coherence of dark microwave static to ordinary visible photons could make possible microwave vision during night time. This could explain why the static emerges after the sunset. Plants could also generate negative energy dark microwave photons with energies in the frequency bands of visible photons involved with photosynthesis to satisfy their metabolic needs when they do not receive sunlight. One can of course wonder whether the quartz in the rock heated during day-time could generate dark microwave photons during night-time serving as a metabolic source.

6. Taos hum as a failure of the electromagnetic immune system

Taos hum starts immediately after the sunrise and stops after the sunset and seems to have a biological origin. The magnetic bodies of (say) plant cells could send dark energy photons at microwave frequencies above 5 GHz: one reason is that they become visible in this manner.

Negative energy W MEs in the same frequency range and responsible for quantum bio-control in the time scale of microwaves could be involved. Due to the failure of the electro-weak immune system the surrounding biosphere could induce generalized motor actions and these would exhaust the metabolic energy resources of the victim. This would explain why the hum is intolerable and the extreme fatigue caused by it.

The radio noise generated by computers and other sources of radio waves should not cause troubles if these radio waves correspond to ordinary photons. If not, then the microwaves in question could provide the energy needed to realize alien control commands based on ELF modulation.

7. An explanation for 40-80 Hz modulation

The model of biological evolution and evolution of nervous system based on dark matter hierarchy [K44] leads to sa detailed identification of the values of Planck constant associated with EEG identified as of dark Josephson radiation with energies in visible and UV range and EEG frequencies. This level is involved with all life forms capable of genetic expression, in particular plants. Therefore the ELF modulation of microwave frequencies could be due to the control commands from the levels of the magnetic body normally meant to control the genetic expression of say plants. The modulation of the microwaves with EEG frequencies, in particular with the frequencies in the $37 - 44$ Hz thalamo-cortical resonance band, could force the patient to stay awake by not allowing the dominant EEG frequencies to drop down to theta and delta region of EEG as occurs during sleep.

8. Is stochastic resonance involved?

One could also ask whether the microwave static of victims of taos hum is anomalously amplified by some mechanism so that control commands from alien magnetic bodies can be realized. The transduction of weak microwave signals to mechanical oscillations by piezo-electric body liquid crystals, and the amplification of this signal in the presence of a metabolic energy feed to the musculature, could lead to this kind of situation.

Stochastic resonance with white noise generated by body provides one possible amplification mechanism. Micro-wave frequency would correspond to the amplified frequency. If so, one could perhaps understand why only some persons experience the hum and why the effect is strong at night time. White noise would be generated by body. White noise induces jumps between the states of the 2-state system with an average frequency f_K (Kramers frequency) which depends on the autocorrelation function of the white noise and the properties of the 2-state system [K95]. If the Kramers frequency satisfies $f_R = 2f$, where f is the frequency of the signal, a resonant amplification occurs. The dependence $f_K \propto exp(-\Delta V/D)$, where $\Delta V > 0$ is the height of the potential barrier separating the states of the 2-state system, implies and exponential sensitivity of f_K on $1/D$, where D is the intensity of the white noise. Hence the failure of the em immune system could be due to the too intense white noise produced by the body of the victim or due a too low height of the potential barrier.

9. Are electronic systems involved with the hum?

The fact that the number of victims of hum has rapidly increased during the era of radio communications and computers and suggests that both radio noise and computers might be actively involved with the hum. Also ELF noise from electronic systems might be important if these systems generate dark ELF photons.

Electronic instruments generate also frequencies in the range $40 - 80$ Hz, in particular the 50 Hz frequency associated with the household electricity. Also submarine radars generate very strong ELF signals. The liquid crystal character of human body implies that besides weak sound signals also these ELF signals can contribute to the signal amplified by musculature. If these signals correspond to the lowest level of dark matter hierarchy, they should not have biological effects but whether this is the case is not all clear.

The strong coupling between magnetic flux tube structures associated the with computer networks and sensory canvases might be created by the magnetic reconnection process during night time when the shape of the flux tube structures changes. Also whole-daily use of a computer could generate magnetic mirror bridges between the computer and user's musculature and allow computer to feed fake control signals to muscles.

Is hum possible in other sensory modalities?

The model of hum based on magnetic sensory canvas suggests that the effect is involved with all sensory modalities. Tactile sensations, in particular pain, are certainly involved. It was already mentioned that hum experiences can involve also perceptions of white light in the horizon in the direction from which hum came. In the model explaining the sensation of hum as being caused by the muscular sound, this sensation could result as a kind of cross-modal association accompanying very intense auditory sensation. In the model explaining the effect as ESP the presence light sensation could be understood as visual aspect of the ESP.

My personal experiences provide a candidate for the counterpart of taos hum in visual field. While closing eyes in a calm state of mind, I see a strange and complex flow consisting of small dots: for the first time I had this experience during my great experience roughly 15 years ago. The effect is easiest to achieve with lightly closed eyes but appears after some time also with tightly closed eyes. For lightly closed eyes the flow is more complex whereas for tightly closed eyes there is just a sink in the middle representing what I would call "third eye", which is present practically always. Vortices and spiral vortices (compare with the whirling winds associated with hums) are typically involved and flow can have also weak coloring.

Could this flow be the visual counterpart of the taos hum? The very fact that the experience is pleasant and the appearance of diffuse white light during taos hum suggests that this interpretation need not be quite correct.

1. The effect is caused by the de-coherence of dark microwave photons or perhaps dark EEG photons above alpha band to visible photons (during calm states of mind alpha band is very strong).

2. This effect is strongest when the eyes are only lightly closed. Perhaps ELF em waves from some source could provide the input to the retina which is magnetic structure and generate the visual sensation somehow (note that rotating non-colored Benham top can generate sensations of color). The de-coherence of dark ELF photons to ordinary visible photons could be the mechanism.

3. I have proposed an interpretation for the flow in terms of the magnetic flux tube structure emerging from the retina. One can however wonder why just single central vortex rather than two? Could it be that pineal gland, which is also a magnetic structure and contains retinal pigments and is "third eye" in rather literal sense, could be responsible for the "third eye" component of the flow, and that during eyes lightly closed conditions turbulent retinal and single vortex like pineal contributions superpose? Could pineal vision be based on the de-coherence of EEG waves above alpha band to ordinary visible photons?

What is perhaps remarkable that the ability to have the flow experience has stabilized during last year or two, which is also the period during which various hum symptoms have developed. However, I experience the flow also when the computer is off: as a matter fact, I experienced the flow for 15 years ago when I did not work with computers.

The recent TGD view of Taos hum

The ideas discussed in this section were inspired by my latest experience with taos hum which I first did not interpret as such.

1. Personal experiences about hum

While learning about taos hum, I suddenly realized that I am perhaps not an objective outsider at all! I cannot tolerate the humming noise of the refrigerator: in order to sleep at all I try to insulate myself from the kitchen by cloth (I do not have door between) and use pillows on my ears in order to get rid of this extremely irritating sound. Even this is not enough and I wake-up very often during night-time. I also used to have terrifying experiences in which the noise of the refrigerator started to increase in volume and my body started to float and was attracted by the refrigerator as if it were a conscious creature wanting to fuse with, or rather steal, my consciousness (by the way this suggests that magnetic selves strongly interacting with my magnetic body might be really involved). I can also hear sounds, such as cracks from wall, as amplified to completely abnormal intensity (in fact I have always had abnormally sensitive ears).

I suffer also from almost intolerable hum of my computer at day-time and only while learning about taos hum, I realized that similar mechanism might be at work also here (note however that taos hum is strongest during night time, between 9 P.M. and 9 A.M.). Remarkably, the hum amplifies when I become conscious of it: I can work long times without noticing its presence at all. Neither am I aware of the refrigerator at daytime. To complete the picture, two years ago I began to suffer from chronic pain in head, neck and back which are due to strong muscle tensions. These pains correlate very strongly with working at the computer terminal. I have believed that

this is due to the bad working ergonomy and poor quality of eye glasses. However it turned out that this was not the reason of pains. I have even suffered from temporal dizziness when pains have been worst and even lost my consciousness once: strangely enough, I heard before the loss of consciousness a strange whirling wind to blow (sic!), and realized only later that weather had been completely calm.

It seems that all these symptoms fit with those of a hum patient. Now only the source of radio waves would be my own computer and would act also at daytime via direct radio wave magnetic mirror bridges connecting the oscillating circuits of the computer to my musculature. When I am not aware of the noise, my brain does not project sensory input from muscles to the auditory canvas and I am saved from the hum sensation. I however feel the pain coming from the body all the time.

On basis of what has been said, it would seem that there is high time to consider the possibility that the electric pollution of environment is gradually making our life increasingly intolerable. One cannot even exclude demon like conscious virus like entities generated by the electronics and computers and fighting for survival with us.

This was however not the full story yet. I suffered from taos hum in my previous hometown. After I moved to my recent hometown, I believed that I had got rid of this problem. But also here I have been tormented from time to time by an unpleasant sensation of sound. Always at night and summertime. The sound source did not move. As if someone were keeping the car idling or even screaming the car engine to drive his fellow men to the brink of rage.

What gave the stimulus to write an article was that after a long period the experience came back at winter time and lasted for several hours. Once again I tried to figure out what it could be. The interpretation as hallucinations didn't seem likely. Another interpretation was as sensory memories. Such are possible and can be induced by electrically stimulating the temporal lobes. For example, some previously experienced pain due to some real cause can be chronically repeated as a sensory memory.

Then I suddenly realized that it was my old friend Taos hum! The reason why I had not realized this from the beginning was that in my new hometown my friend has been much more aggressive and created the impression of intentional bullying so that the unavoidable first impression was that some-one is terrorizing his neighbors by gassing his car at night-time.

2. Taos hum and quantum gravitation

The latest experiences with taos hum led to an identification of new pieces, which seem to fit the puzzle of taos hum.

If taos hum corresponds to microwave hearing, the natural question is what the range of the carrier frequencies is and whether there are some special carrier frequencies.

1. In quantum biology based on TGD quantum gravity is essential [L119, L116]. Nottale's hypothesis [E2] is generalized and assigns macroscopic and even astrophysical quantum coherence to classical gravitational fields created by astrophysical objects.

   In the Earth's gravitational field, the gravitational Compton wavelength is $\Lambda_{gr} = GM_E/\beta_0$, where the velocity parameter satisfies $\beta_0 = v_0/c < 1$. Λ_{gr} and the corresponding frequency f_{gr} do not depend on the mass of the particle (Equivalence Principle). For $\beta_0 = 1$ one has $\Lambda_{gr,E} = .45$ cm. It corresponds to the microwave frequency $f_{gr,E} = 67$ GHz. This would be some kind of universal clock frequency of quantum biology.

2. I have considered also the possibility that computers [L130, L129, L134] could acquire some characteristics of a biological organism, if their clock frequency is higher than this frequency, because then the statistical determinism would no longer apply. In fact, the corresponding wavelength associated with the Sun is half the radius of the Earth and corresponds to the frequency $f_{gr,S} = 50$ Hz which is EEG frequency, which inspires many questions.

3. For biomolecules, microwave frequencies play an essential role. Microwaves are associated with many strange effects such as ball lightning and light balls that have often been interpreted as UFOs. The creation of crop circles [K41, K42] [L134] could be based on the same mechanisms as the explosion of a tomato in a microwave oven, which can be also used to produce this kind of light balls. There are also reports of lightballs in the act of building a crop circle.

4. Could the amplitude modulation of the radiation with gravitational Compton frequency $f_{gr,E}$ of the Earth produce the taos hum?! The modulating frequencies are in the EEG range and quite low, which brings in mind the gravitational magnetic body of the Sun with $f_{gr,S} = 50$ Hz.

5. What would give rise to the impression of an idling diesel engine? Could it correspond to some kind of random noise but what about the impression of deliberate gassing? What comes to mind is a boxer who is in a state of maximal alertness ready to attack at any moment. This suggests a quantum critical state in which bursts of metabolic energy are randomly occurring. Note that the carrier frequencies would be microwave frequencies and by a factor of 67 higher than in the Frey effect, which has been associated with the microwave hearing.

There is also another important microwave frequency. The maximum for the frequency distribution of the cosmic microwave background is at the frequency 160 GHz and to wavelength .2 cm. This frequency is roughly twice the gravitational Compton frequency for Earth. This is close to the upper limit of microwave frequencies of 300 GHz. Is it a coincidence that these two frequencies are so near to each other?

3. Taos hum and TGD based generalization of stochastic resonance

Stochastic resonance [D25] [J49] occurs in the brain [D43] and its quantum analog serves as a candidate for the mechanism behind the perception of taos hum.

Consider first the classical variant of the stochastic resonance, which I have considered in [K95].

1. Classical stochastic resonance is an amplification mechanism for a signal represented as an amplitude modulation of a carrier wave with a basic frequency f acting as a harmonic perturbation of a bistable system, which is also subject to a white noise. In the recent case the message could correspond to the amplitude modulated signal with frequency f in the microwave range. $f = f_{gr}$ is an interesting option. One might say that the system manages to extract the energy of the noise, which creates the question whether the mechanism conforms with the second law of thermodynamics.

2. In the resonance, the signal frequency f must be one half of the average frequency $f(spont)$ for the jumps between two states of the bistable system: $f = f(spont)/2$. This condition has a simple physical interpretation: the height of the potential barrier separating the two potential wells varies periodically with a period which is half of the period defined by f, and the best opportunity to get to another potential well is to hop when the potential barrier is lowest possible.

3. For the mechanical analog system the rate $f(spont) = r_0 A$ is proportional to an "Arrhenius factor" $A = exp(-\Delta V/D)$, where ΔV is the height of the potential barrier and D characterizes the intensity of the white noise. $f(spont)$ is also proportional to a factor $r_0 = \omega \omega_b / \gamma$ where ω is the frequency of small oscillations at either bottom of the symmetric potential well, ω_b is the analogous quantity at the top of the barrier (for harmonic oscillator potential one would have $\omega = \omega_b$), and γ characterizes the linear dissipative force (overcritical damping is assumed).

4. Thus, when the white noise has a correct intensity, a weak harmonic perturbation with a given frequency is amplified in the sense that the Fourier expansion of the system's time development regarded as jumps between the two states contains a peak at the multiples of the frequency of the amplitude modulated harmonic perturbation. Neuroscientists refer to this phenomenon as phase locking. The peaks for the higher multiples of the input frequency f are exponentially suppressed. The notion of stochastic resonance makes sense also in the quantum context: now quantum tunnelling would replace the jumps induced by the stochastic noise.

Could stochastic resonance generalize to a quantum situation but with the ordinary ontology of quantum theory replaced with the zero energy ontology (ZEO) of TGD [K126]? What would be new is the identification of the ordinary quantum jump as a "big" state function reduction (BSFR) in which the arrow of time changes. One can consider two interpretations.

1. Consider first the TGD analog of the standard interpretation. The jump between the potential wells corresponds to a quantum tunnelling as a transition of states with the same arrow of time and therefore involves two subsequent BSFRs. In stochastic resonance, the frequency $f(spont)$ for these tunnellings should satisfy $f = f_{spont}/2$. Each period $T = 1/f$ would correspond to two pairs of BSFRs. In the TGD framework, this interpretation looks too complicated.

2. For the second option, a single BSFR defines the counterpart for the hopping between two potential wells and 2 BSFRs define quantum tunnelling. Bistability has nothing to do with the details of the dynamics and is universal and corresponds to the two arrows of time. $f(spont)$ is identified as the rate for BSFRs rather than their pairs and characterizes external perturbations.

   In the stochastic resonance, the rate $f(spont)/2$ for a pair of BSFRs would be equal to the carrier frequency f so that quantum tunnelling is in synchrony with the driving frequency f and each period corresponds to a quantum tunnelling. The intensity of the noise could be used to induce this synchrony.

   This synchronization mechanism applies to all transitions and to all frequencies f but $f = f_{gr,E}$ would be in a special role since $f_{gr,E}$ defines a universal gravitational Compton frequency of the Earth. For instance, EEG could involve this mechanism and the halves of the EEG period would correspond to different arrows of time as I have indeed proposed in [K95] on basis of observations of brothers Fingelkurts [J46]. As already noticed, the gravitational Compton frequency $f_{gr,S} = 50$ Hz of Sun is EEG frequency and EEG frequencies appear as modulation frequencies in Taos hum.

5.7 Evidence for quantum brain

The recent findings suggest quantum coherence in the brain scale. The quantum coherence would make itself visible in the magnetic resonance imaging (MRI). The findings are described in the popular article in Scitechdaily (`https://cutt.ly/0NtnxwZ`). The research article "Experimental indications of non-classical brain functions" by Christian Matthias Kerskens and David Lopez Perez [J29] is published in Journal of Physics Communications (`https://cutt.ly/0NtnEKz`).

The system studied is the brain and cyclotron resonance of protons in "brain water" is involved. The goal was to find whether there exists evidence for macroscopic quantum entanglement. The work was based on the proposal that some quantum coherent, non-classical, third party, say quantum gravitation, could mediate quantum entanglement between protons of brain water. NMR methods based on so-called multiple quantum coherence (MQC) act as an entanglement witness.

The work of Kersens and Perez was inspired by a theoretical work of Bose et al in which a possible method allowing to witness quantum gravity by spin entanglement [B14](`https://cutt.ly/CNhF2Ev` was discussed.

In the sequel, the proposal of Bose et al for generating entanglement by quantum gravitational interaction between mesoscopic objects is first discussed. A superposition of two locations for the objects is required. It is assumed that it is possible to correlate the locations with spin values. Entanglement would be generated by different phases, which evolve to different pairs of components of objects and measurement of spin would demonstrate the presence of entanglement.

Mechanisms generating quantum coherence in scales of at least 10^{-4} meters and giving rise to a superposition of locations are needed but are difficult to imagine in the standard view of quantum gravitation.

In TGD, the mechanism would be different. Gravitational Planck constant $\hbar_{gr} = Gm/v_0$ associated with Earth-test particle interaction could generate quantum coherence in even brain scale and gravitational Compton length $\Lambda_{gr} = GM/v_0 \simeq .45$ meters, where $v_0 \simeq c$ a velocity parameter characterizes the lower bound for the quantum gravitational coherence scale. The analogs of magnetized states assignable to microscopic objects of size scale 10^{-4} meters take the role of spins and spin-spin interaction generates the entanglement, which is detected by measuring the spin of either object just as in the case of ordinary spins.

5.7.1 Could spin entanglement be used as a witness for quantum gravitation

The basic idea of the two [J29] and [B14] is that quantum gravitation can be witnessed by the entanglement induced by it.

5.7.2 Could quantum gravitation generate spin entanglement for quantum superpositions of locations?

In the article "A Spin Entanglement Witness for Quantum Gravity" of Bose et al [B14](`https://cutt.ly/CNhF2Ev` a detailed proposal how the quantum gravity could generate entanglement in scale $d \sim 10^{-4}$ meters.

1. The masses $m_1 = m_2 = m$ considered are of order 10^{-14} kg and would correspond to a water blob of size about 10^{-5} m with mass of order $m \sim 10^{-3} m_{Pl}$. The masses m_i would be at a distance $d \sim 100 \ \mu m$, which corresponds to the size of a large neuron having mass about Planck mass. One has $\alpha_{gr} = Gm^2/\hbar \sim 10^{-6}$. So that the interaction energy at distance d would be $Gm^2/d \simeq 10^{-8}$ eV, which is much below the thermal energy.

2. The idea is that although the gravitational interaction energy is quite too small, quantum gravitational interaction between masses m_i could be detectable via a generation of quantum entanglement. The additional assumption, bringing in mind the Orch-OR hypothesis, is that superpositions of 2 locations are possible for the masses and the separation scale Δx is of order $d/10$. The mechanism causing this superposition is not discussed. What comes into mind is gravitational double well potential.

3. One considers a situation in which each mass is a superposition L+R of locations for the center of mass. One assumes that it is possible to assign to the locations L and R opposite spins so that the measurement of spin would perform a state function reduction inducing a localization to either R or L configuration.

    The distance of the masses has the scale d. One assumes that the masses behave like quantum coherent objects describable by a scalar field, and assumes that they fall freely in the gravitational field of Earth for a time of order of a few seconds.

4. The mathematical model assumes standard perturbative quantization of the gravitation using quantum field theory in Minkowski space. The situation is assumed to be static so that only the component g_{tt} of the metric and radiation part of the gravitational field matters in the description of the interaction.

5. The initial state is an unentangled product of states but their mutual quantum gravitational interactions LR and RL corresponding to distances $d + \delta x$ and $d - \delta x$ of masses generate different phase factors. After this, these analogs of photon beams superpose again and interference takes place. The predicted difference of the phase angle is of order 10^{-4} and might be measurable with recent technology.

5.7.3 NMR as a witness for quantum gravitational entanglement

The experiment carried out by Kerskens and Perez [J29] was not based on interferometry but on nuclear magnetic resonance imaging (MRI).

It is far from clear that the ordinary NMR signals can contain quantum correlations of the spectrum in the hot and wet brain environment. Therefore a witness protocol, which eliminated the "classical" background from known sources was used.

To achieve this, the "classical" sources of entanglement had to be eliminated. This was achieved by irradiation of the brain region with a radiation inducing cyclotron transitions to higher energy state so that the situation would become saturated and one would have a statistical dynamic equilibrium. In a statistical sense, the temporal patterns associated with the transitions from a higher state to a lower state causing cyclotron radiation patterns visible in MRI would be absent. In this back-ground the presence of "non-classical" sources of cyclotron emission would be visible.

This source could correspond to a formation of pure entangled state which would decay by emitting cyclotron radiation.

What was found, was a periodic pattern in MRI with a frequency of heart beat, interpreted in terms of evoked membrane potentials. This pattern is too weak to be visible in the ordinary MRI. What looks surprising is that the frequency was that of heart beat; one would expect some resonance frequency of EEG, say 10 Hz. Premumably, the the possible evoked potentials due to the heartbeat were intentionally chosen as as a target of attention.

The finding fits very nicely with the TGD view of brain and quantum biology, in particular the TGD view of genetic code [L75, L123, L108, L122].

1. In the simplest model, sequences of dark protons (ordinary protons with effective Planck constant $h_{eff} = nh_0$, which can be very large) at the flux tubes of the magnetic body associated with DNA would realize genetic code as sequences of dark proton triplets. Besides dark nucleotides, also dark codons and dark genes as quantum coherent dark 3N-protons would be possible and characterized by very large value of h_{eff}.

   Also dark photon triplets would realize codons and give rise to dark genes as sequences of dark codons: 3N-photons. Communications between dark genes and would occur using dark 3N-photons by dark 3N-resonance. The 3N-frequency would serve as an address somewhat like in LISP and the modulation of frequency scale would create a sequence of resonances analogous to sequence of nerve pulses.

   EEG would closely relate to the dark photon radiation between the magnetic body and brain. Also generalizations of EEG to other frequency ranges are suggestive.

2. The dark magnetic flux tubes would be associated with water and its numerous thermodynamic anomalies and exceptional role in biology, could be understood by the presence of a dark phase involving long gravitational flux tubes carrying dark protons with $h_{eff} = h_{gr}$.

   The required values of h_{eff} are huge, and this led to a connection with the Nottale hypothesis of gravitational Planck constant $\hbar gr = GMm/v_0$, $v_0 \leq c$ is a velocity parameter. One would have $\hbar_{eff} = \hbar_{gr}$. The value of velocity parameter can be estimated from various applications. It would have a spectrum with the largesty value $v_0/ \simeq 1$ in the case of Earth with $M = M_E$.

3. TGD leads also to an identification of B_{end}. TGD predicts monopole flux tubes (CP$_2$ homology is non-trivial) distinguishing TGD from Maxwellian electrodynamics. $B_{end} = 2B_E/5$ is identified as the monopole flux part of the Earth's magnetic field. The monopole flux tubes would carry dark matter and since they have huge quantum coherence scales, would naturally control ordinary biomatter. The control would involve frequency modulation by the variation of the thickness of the monopole flux tubes which would affect the field strength by the conservation of the monopole flux. The variation of the frequency scale would induce at the end of the receiver sequences of cyclotron resonance analogous to nerve pulse patterns.

4. Magnetic body of DNA carrying dark DNA is expected to act as controller of the ordinary biomatter using cyclotron resonance mechanism. In particular, important biorhythms could correspond to cyclotron frequencies. Heartbeat defines one such biorhythm.

   DNA nucleotide cyclotron frequencies are about 1 Hz for B_{end} assigned to the monopole flux tubes. Also for DNA sequences, such as codons and genes, the average cyclotron frequency would be around 1 Hz because the nucleotides carry the same charge and charge to mass ratio Ze/m, so that the cyclotron frequency depends only very weakly on the length of quantum coherent dark DNA segment.

5. The variation of the heart beat frequency could be understood in terms of the variation of the monopole flux tube thickness for dark DNA. This variation would be basic motor action of MB making possible control of biomatter using frequency modulation inducing sequences of resonances manifesting as pulses. Nerve pulse patterns could be one manifestation of this mechanism.

5.7.4　How quantum gravitation could generate spin entanglement in TGD Universe?

One source of theoretical inspiration for the work of Kerskens and Perez [J29] was the article "Spin Entanglement Witness for Quantum Gravity" of Bose et al [B14].

Classical interactions, be their gauge or gravitational interactions, cannot generate entanglement whereas their quantum counterparts do so in scales smaller than the scale of quantum coherence.

1. The first open question is whether quantum gravitation is able to generate quantum coherence in long length scales such as the scale of the brain. The fact that gravitation has infinite range and is unscreened might allow this. This however requires a new view of quantum gravitation.

   A gravitational 2-particle interaction or interaction induced by quantum gravitation is needed to entangle the systems. If spins or possibly magnetizations are in question, the entanglement can be detected by spin measurements as done in the experiment. The interaction must be such that it can be distinguished from ordinary magnetic interactions.

2. If objects with mass above Planck mass behave like quantum coherent particles with respect to quantum gravitation rather than consisting of small quantum coherent units such as elementary particles, the gravitational fine structure constant $\alpha_{gr} = GM_1 M_2/\hbar$ between objects satisfying $M_1 M_2 > m_{Pl}^2$ becomes strong and one expects that the situation becomes non-perturbative.

   The condition $M_1 = M_2 = m_{Pl}$ is satisfied for a water blob of radius $\sim 10^{-4}$ meters and corresponds to the size of a large neuron [L94, L122]. The gravitational interaction energy $GM_1 M_2/d$ for distance $d \sim 10^{-4}$ m is about 10^{-2} eV and of the same order of magnitude as thermal energy.

3. In the interferometer experiment a much larger phase difference could be generated in the TGD framework but the problem is that it is difficult to imagine a mechanism for creating a superposition of 2 locations of mesoscopic or even microscopic objects.

4. It is also difficult to imagine a mechanism creating 1-1 correlation between location and spin direction (analogous to entanglement associated with spin and angular momentum).

The notion of gravitational Planck constant

The basic problem is what makes the quantum coherence scale so long.

1. In the TGD framework, the non-perturbative character of the situation for $Mm \geq m_{Pl}^2$ motivates a generalization of the Nottale's hypothesis stating that the gravitational Planck constant $\hbar_{gr} = GMm/v_0$, $v_0 < c$ a velocity parameter. $\hbar_{eff} = nh_0 = \hbar_{gr}$ would be associated with gravitational flux tubes to which interacting masses M and m are attached, and would replace $\hbar$ with the gravitational fine structure constant $\alpha_{gr} = GMm/\hbar > 1$ meaning that $Mm > m_{Pl}^2$ is true. One could say that Nature is theoretician friendly and makes perturbation theory possible. This applies also to other interactions.

   The gravitational Compton length $\Lambda_{gr} = GM/v_0$ does not depend on the mass m at all. For the mass of order Planck mass assignable to a large neuron one has $\Lambda_{gr} = L_{Pl}/v_0$, which is of order Planck length. Much longer quantum coherence scale is however required.

2. In the case of the Earth, the basic gravitationally interacting pairs would be Earth mass and particles of various masses. The gravitational Compton length $\Lambda_{gr,E} = GM_E/v_0$ does not depend on the small mass and is about .45 cm for $v_0 \simeq c$ favored by TGD applications. By the way, this scale corresponds to the size of a snowflake [L116].

   $\Lambda_{gr,E} \simeq .45$ cm defines a minimum value for the gravitational quantum coherence scale but much larger coherence lengths, say of order Earth radius, are possible. The size scale of the brain or even body would define a natural scale of quantum coherence. For objects with a size of order of a large neuron, the gravitational interaction could be quantal in scales of the brain, and actually in the scales of the magnetic bodies assignable to the organism.

3. Earth-particle interactions can induce quantum coherence in the scale of the brain and the masses could be taken to be of the order of Planck mass so that they would correspond to water blob with size of 10^{-4}, so that their distance could be larger than d. This raises the hope that the effects of quantum gravitation quantum coherent in cell length scale or even longer scales could be measured although the interaction itself is extremely weak for elementary particles.

4. For $r = 10^{-4}$ meters, $M = M_E$ would give $E \sim e^2/410^2$ eV ~ 2.5 eV. For $r = 5 \times 10^{-4}$ meters this would give $E \sim .01$ eV, roughly the thermal energy at the physiological temperature.

TGD allows the possibility of detecting gravitational interaction energies for objects of mass of say Planck mass or larger. In fact, the large value of gravitational Planck constant increases the extremely tiny cyclotron energies of ELF photons in EEG range to energies above thermal energy at room temperature [K60, K89, K90] [L123].

A possible TGD based mechanism generating spin entanglement

These considerations suggest a TGD based mechanism for the generation of spin entanglement, which is not directly based on quantum gravitational interaction but on microscopic and even macroscopic qravitionally induced quantum coherence making possible a generalization of the spin-spin interaction as a way to generate entanglement.

1. Spin should correspond to an analogs of macroscopic magnetization rather than individual spin. Spin-spin interaction between "mesoscopic" defined by quantum coherent particles characterized by $\hbar_{gr}$ and having mass about Planck mass generates the entanglement which can be detected by measuring the "spin" of either particle. As a consequence also the "spin" of the other particles is determined and one has a standard situation demonstrating that the particles were entangled before the measurement.

   Large value of the energy due to the large value of $\hbar_{gr}$ could mean that one has a dark Bose-Einstein condensate like state with a large number of ordinary particles, say protons at the gravitational flux tube representing the quantal magnet behaving like spin.

   In the TGD framework, Galois confinement provides a universal mechanism for the formation of many-particle bound states from virtual particles with possibly momenta with components in an extension of rationals . The total momentum would have integer components using the unit defined by the size scale of causal diamond (CD).

2. The dark cyclotron energy $E_c = \hbar_{gr}eB/m = \Lambda_{gr}eB$, $\Lambda_{gr} = GM/v_0$ of a mesoscopic particle whose particles are associated with (touching) the dark monopole flux tubes of the Earth's gravitational field, does not depend on its mass and is large.

   The magnetic field created by this kind of particle would correspond in the Maxwellian picture to a field $B \propto \hbar_{gr}e/mr^3$. This would give for the magnetic interaction energy of the mesoscopic particles the estimate $E \sim \mu_1\mu_2/r^3 = e^2\Lambda_{gr}^2/r^3$.

5.8 TGD based model for the solar magnetic field, solar cycle, and gamma ray emission

Sabine Hossenfelder gave a link to a popular article (see `http://tinyurl.com/y6mpuggu`) telling about rather shocking new findings about Sun.

5.8.1 Solar surprise: looking sunspots again after decades

There are 5 times more gamma rays than expected and the spectrum has a deep and narrow dip in 30-50 GeV range. Spectrum continues to much higher energies than expected, at least up to 100 GeV. One proposal is that there could be dark matter in the interior of Sun yielding the gamma rays but is unclear how they could get to the surface without experiencing the same fate as the ordinary gammas from nuclear reactions. There is also a correlation with sunspot cycle

(see `http://tinyurl.com/aqw2hmz`). Basic data and observations related to correlations with the solar cycle are described in the article [E5] (see `http://tinyurl.com/yxajyzp8` and [E4] (see `http://tinyurl.com/y2qlaaa2`).

1. Power law spectrum is harder than for cosmic rays: spectral indices are $n = -2.2$ and $n = -2.7$ respectively (one has power law behavior E^n for the flux). The spectral intensity at 100 GeV is very nearly the maximum flux predicted by the model assuming that reflection of cosmic gamma rays explains the gammas.

2. The spectrum has two components: poloidal component farther from equator and equatorial component largest during sunspot minimum. The equatorial contribution is maximal at solar minimum. The spectral index of the equatorial contribution is harder and higher energies are present. The energy range is maximal during spot minima. Gamma flux is reduced during sun spot maxima.

   How the observed gamma rays could be produced in TGD Universe?

1. Gamma rays cannot cannot be produced by nuclear reactions as ordinary gammas since nuclear energy scale is much below the scale of gamma rays extending to 100 GeV at least. Even the hadronic energy scale is too low. The gamma rays could be cosmic rays having already high energies: the spectral indices are however different. This leaves acceleration of charged particles producing gamma rays as the most plausible mechanism irrespective of whether the charged particles come from solar core or are cosmic rays.

2. Dark magnetic flux tubes are basic notion of TGD and could serve as the channels along which charged particles could propagate to the surface without losing their energies in collisions. An interesting hypothesis considered already earlier is that solar magnetic field are what I call wormhole magnetic fields [K125] consisting of closed monopole flux tubes with flux and return flux at different space-time sheets connected by tiny wormhole contacts. This would predict that the flow is not evenly distributed but reflects the structure of the flux tube distribution. If the flux tubes have same M^4 projection they cause no effects on test particle and behave like dark energy creating only long range gravitational fields.

   Charged particles could accelerate in the electric field of flux tube as they travel along flux tubes and generate gamma rays by some mechanism. The energy would be the increment of Coulomb energy if dissipation is neglected. A simple modification of flux tube type extremals allows the presence of helical magnetic and electric fields along flux tube orthogonal to each other. I have proposed the same mechanism to explain the gamma rays and high energy electrons at MeV energies associated with lightnings [K26]: in standard physics framework dissipative losses do not allow them.

3. What could be the production mechanism of gamma rays? If flux tubes have sharp kinks, charged particles should experience large deceleration in the kinks and could emit high energy gamma ray in the process. The highly relativistic charge particle itself could leak out (one cannot exclude nuclei from solar core). Large deflection angles however requires transfer of momentum also to flux tube degrees of freedom.

4. What could be the origin of the tip around 30-50 GeV? If the acceleration takes place in the electric fields assignable to the closed flux tubes assignable to solar dipolar magnetic field, the charged particle could travel several times around the loop giving rise to several energy bands explaining the gap and suggesting several of them. The flux loop would act as a particle accelerator.

5. The charged particles could be provided by the solar core or they could be cosmic rays. The order of magnitude for gamma ray intensity is 5 times larger than in cosmic ray model, which encourages the identification as cosmic rays (see `http://tinyurl.com/psdp99h`). The origin of cosmic rays is however also a mystery and neutron stars, supernovae, active galactic nuclei, quasars, and gamma-ray bursts have been proposed as sources of cosmic rays.

   A possible mechanism producing cosmic rays could be pair-annihilation of pairs of M_{89} pions with mass about 70 GeV [K71] to gamma ray pairs or charged particles with energies 35

GeV. Could the dip observed in the energy range around 30-50 GeV somehow relate to the charged decay products of M_{89} pions accelerating in the electric fields of flux tubes? Could the dip be gap without the decays of M_{89} pions?

In TGD the model for the formation of galaxies, quasars, and active galactic nuclei, and even stars, and planets relies on the formation of looped tangles along long thickening cosmic strings with topology resembling that of dipole magnetic field. Galactic matter would be produced by the decay of the flux tube energy to particles as analog of the decay of inflaton field. This could generate both charged particles and gamma radiation in the solar core and in neutron stars. The acceleration could be much more effective due to the strong magnetic and electric fields involved. Also charged particles can leak out from the flux tubes and cosmic rays could be produced by this mechanism. Cosmic rays could move along the highways defined by the long magnetic flux tubes connecting galaxies.

The understanding of the correlations with the solar cycle requires a model for the polarization flip. One can consider several options but the model based on reconnection splitting dipole loops from the flux tube tangle representing the analog dipole field is the simplest one. The simplest variant of the model requires zero energy ontology (ZEO) and quantum coherence at dark flux tubes in solar length scales and that long galactic string defines wormhole magnetic field with two sheets (type I and II) connected by wormhole contacts separated from each other in the sense that M^4 projections are disjoint.

1. Let us denote the numbers of dipole loops of type $i = I, II$ by n_i. Assume that in the initial situation one has $(n_I = n_{max}, n_{II} = 0)$. B as maximum value B_{max}. The arrows of time at the two sheets are assumed to be opposite during cycles.

2. The transition leading $B = B_{max}$ to $B = 0$ would be "big" state function reduction (BSR) changing the arrow of time at sheets of both type I and II. BSR would generate maximum number of new dipole flux loops of type II: $n_{II} \to n_{max}$ so that one has $n_I = n_{II} = n_{max}$ and $B = 0$.

3. After that dipole loops of type I begin to split away by reconnections in "small" state function reductions (SSRs) so that n_I decreases. They split further in pieces and leak out from Sun whereas n_{II} remains unchanged since it corresponds to the passive boundary of CD - this is essential. Net B increases until one has $B = -B_{max}$.

4. Next occurs BSR generating maximum number of new flux loop portions of type I leading $n_I = n_{II} = n_{max}$ and $B = 0$ and same is repeated except that now n_{II} decreases.

5. One can understand the sunspot cycle in terms of split dipole loops leaving the Sun: their intersection with the solar surface would define sunspot pair and the distance of members of the pair would decrease to zero during the cycle.

The model leads to rather dramatic predictions.

1. Various magnetic structures are predicted to appear in pairs with members related by an approximate Z_2 symmetry. For the magnetic field of the Sun this symmetry would be naturally inversion symmetry with respect to the surface of Sun. Also reflection symmetry can correspond to Z_2. This symmetry should be universal and the predictions are in sharp contrast with the locality principle of classical physics. One could even understand the mysterious "Axis of Evil" associated as anomaly of CMB and apparently giving special role for solar system (see http://tinyurl.com/yb6nabw4).

2. Also unexpected connections with TGD inspired views about biology and consciousness emerge. Magnetic body (MB) is the intentional agent in living system Z_2 realized as inversion could related the parts of MB in the interior and exterior of Earth: could the idea about intra-terrestrial life introduced originally half-jokingly [K60, K62, K41, K41] make sense - at the level of MBs at least? ZEO based theory of consciousness predicts that conscious entities can have both arrows of time and death means reincarnation with opposite arrow of time. But where do these ghostly selves with opposite arrow of time reside? Could Z_2 - possibly realized as inversion - relate these selves to each other.

5.8.2   How the magnetic fields of galaxies and stars are generated?

To get a general enough perspective about the generation of time dependent B, one must consider the general model for how the magnetic fields of galaxies, stars, and planets are generated.

1. The magnetic fields of galaxies, stars, and planets would have formed as tangles along cosmic strings thickened to magnetic flux tubes carrying monopole flux. . Tangles would be formed by the flux tubes forming knotty structures with flux tubes defining analog for subset of flux lines of dipole field. The flux tubes can organize in several ways.

   Cosmic strings would be wormhole magnetic fields carrying opposite monopole fluxes at space-time sheets connected by wormhole contacts (in principle it is possible to consider also single-sheeted monopole fluxes). I will talk about sheets of type I and II. If the flux tubes are on top of each other in the sense that M^4 projections are identical, the magnetic field experienced by test particle touching both flux tubes would vanish. The fact that the energy of the flux tubes gives rise to gravitational field can be used to argue that one can talk about dark energy in this case. The flux tubes can be connected by extremely short wormhole contacts at places, where they are on top of each other. If the Euclidian wormhole contacts can have tube-like M^4 projection, they would be also flux tube like.

2. It is not clear whether the flux tubes of both type I and II are inside the volume bounded by Earth's B or whether second type of flux tubes are outside Earth. This gives rise to several options for how B can be realized as flux tube field and how the time dependence of B is obtained.

3. One can imagine two options, which apply to both types of fluxes separately. For the most general option (Option I) the incoming flux tube can divide to smaller flux tubes going both to the interior and exterior of the dipole core. The extreme options (Option II and II) are that it flows entirely to the dipole core or divides to flux tubes travelling outside the dipole core (this situation is analogous to hydrodynamical flow past obstacle). It will be found that option II is most attractive one.

4. Incoming flux long tube at given sheet forms a tangle. Consider first the tangle formed by the incoming long flux tube of given type at fixed space-time sheet, for definiteness restriction the consideration to flux of type I..

   (a) For Option I the neighbouring flux portions of the flux tube portions inside and outside dipole core can have random orientations: this would be like random spin system without any magnetization. The average observed field would be random. For Options II and III this kind of situation is not possible.

   (b) The flux tube in the tangle can also arrange like spins in spontaneous magnetization so that neighboring portions of the flux tube are parallel both inside the core and outside it. The flux and return flux would be at different sides of the dipole core. This could give rise to an analog of say dipole field. For instance, dipole core could correspond to a spherical volume bounded by the Earth's surface. The extreme situation would correspond to Option II or III.

5. For Option I the polarity of observed B could be due to a process analogous to spontaneous magnetization, whose degree can vary. The degree of magnetization would be determined by the ratio of the incoming fluxes going to the interior and exterior of the dipole core. The total flux Φ flowing inside dipole core is $\Phi = (p_1 - p_2)\Phi_{in}$, where p_i are the fractions of incoming fluxes going inside the dipole core and outside it. If the ratio equals to unity the net B vanishes in long enough scales. For Options II and II one cannot have time varying B unless the number n_i, $i \in \{I, II\}$ of dipole loops can vary.

   Polarization reversal could be a dynamical process. For the analog of hydrodynamical flow the portions of the flow going through the dipole core and its exterior could change, and the fraction of these portions is the parameter determining the strength B. Oscillating B would mean oscillation of this fraction. Also the numbers n_i change and induce change of B.

6. If the flux tubes of both types are in the volume carrying B, more possibilities arise for Option I since the flux tube portions of type I and II can have magnetizations of varying degree and these can be parallel or opposite inside (outside) dipole core.

7. For Options II and III the magnetization direction cannot vary unless n_i can change and the total average magnetic field would vanish for $n_I = n_{II}$. n_i can however change if dipole loops split away by reconnection. It turns out that option II is the most promising one.

5.8.3   A model of solar magnetic field in terms of monopole flux tubes

The model relies on the notion wormhole magnetic field with flux tubes carrying electric fields, the notion of reconnection, and the theory of quantum measurement based on zero energy ontology (ZEO) [K75] and extending to a theory of consciousness [L53].

    Also hydrodynamic analogy, the analogies with ferromagnetic hysteresis cycle, spontaneous magnetization, and de-magnetization, the analogy with the Meissner effect explaining solar spots as magnetic flux branching from the dipole axis of solar magnetic field, and Lenz principle (induction law) stating that magnetic field generates ohmic current in turn generating magnetic field opposing the change of the magnetic field , are used as guidelines.

1. One can argue that the magnetic fields in question correspond to flux tube portions carrying monopole flux. The empirical support for the hypothesis comes from the fact that monopole fluxes need no currents to generate them. Cosmology is indeed full of long range magnetic fields whose presence is mystery in Maxwellian electrodynamics.

2. Interaction of two kinds of magnetic fields would be involved. The first magnetic field identified as solar magnetic field, call it B, is assumed to have flux tubes wormhole magnetic field carrying monopole fluxes. No current is needed to create the magnetic flux: something impossible for ordinary Maxwellian fields. Note also that the cross section of flux tube is closed 2-D surface. One could call B topological magnetic field. Mathematically B could be seen as an analog of the external magnetic field H generating as a response total magnetic field as a sum of H and magnetization M.

   Second magnetic field, call it B_1 would be Maxwellian and generated by Faraday induction. By Lenz principle it opposes the change of the magnetic flux associated with B and has roughly the same direction. B_1 would correspond to M. In the proposed framework the induced currents j would generate B_1 and it would be regarded as secondary rather than primary field.

   Remark: The flux tubes of B_1 would be obtained from closed string like objects with CP_2 projection which geodesic sphere S^2 by replacing S^2 with disk D^2, by deforming to get flux tube, and gluing it to a large background space-time sheet along D^2. The current creating B_1 would be associated with the boundary of D^2.

   One cannot of course exclude the Maxwellian option for B.

1. The portion of flux tubes of B identifiable as analog of the dipole core of Maxwellian dipole field would consist of particles with magnetic moment whereas for monopole flux no magnetic moment is needed. Magnetic moment could be due to spin or orbitals motion.

   Remark: One could wonder whether quantum-classical correspondence (QCC) requires that the monopole flux has as quantum counterpart magnetization representable in terms of fermions.

2. The contribution of the spin to magnetic field is rather small so that the idea about spontaneous magnetization at flux tubes defining dipole does not look promising. Note however that the large value of h_{eff} together with proportionality of $\mu \propto \hbar_{eff}/m$ could change the situation. Macroscopic quantum coherence making possible quantum states with macroscopic radius for the orbits could be considered and would conform with the idea that the flow of currents generates B. B could be of course generated also classically.

5.8.4 Are wormhole magnetic fields really needed?

The additional assumption is that wormhole magnetic fields involving two space-time sheets connected by wormhole contacts appear in the volume containing B. More generally, fundamental magnetic fields would be wormhole magnetic fields. This additional hypothesis is necessary in the recent model of elementary particles and p-adic fractality suggests that the property holds true also astrophysical scales.

1. In elementary particle scales monopole flux tubes associated with wormhole magnetic fields must be closed and involve return flux along second space-time sheet. If the two space-time sheets have same M^4 projection, the test particle touches both sheets and experiences essentially no gauge fields. At QFT limit one would have no fields. Therefore the M^4 projections of the flux tubes at the two sheets must be disjoint in order that one has normal magnetic field in operational sense.

   The energies of both flux tubes however sum up and the wormhole flux tube pair has long range gravitational interactions. The attractive interpretation is that if the volumes in which the sheets have same M^4 projection, the energy of flux tube pair corresponds to dark energy. The portions giving rise to tangles in which the flux sheets have separate projections give rise to ordinary matter. This would give rise to galaxies, stars, and planets and even smaller objects in various scales. Flux tubes would thicken and their energy would decay to ordinary and dark matter.

2. Wormhole magnetic fields could define pairs of systems. The understanding of the geometric correlates for the hierarchy of Planck constants have already led to the realization that many-sheeted space-time means that one space-time surface can be regarded as n_1-fold covering of CP_2 and n_2-fold covering of M^4 such that one has $h_{eff}/h_0 = n = n_1 n_2$ holds true. For n_1-fold covering of CP_2 the sheets can be disjoint regions of M^4. Although the regions are disjoint, they are physically closely correlated. This is classical correlate for macroscopic quantum coherence coded also by the large value of n.

   For $n_1 = 2$ one obtains the simplest pairs. Also even values of $n_1 = 2m_1$ are of course and would describe a pair of structures with m_1 components. The components would be most naturally flux tubes fusing to larger flux tube fractally.

3. This view becomes understandable if one takes CP_2 coordinates or $M^2 \times CP_2$ coordinates as a coordinate system so that the roles of space-time and fields are changed or partially changed. At the level of wormhole contacts the change of the roles of M^4 and CP_2 is necessary. For string like objects $M^2 \times S^2$ replaces M^4. This corresponds to that part of TGD, which does not allow description in terms of GRT.

   Playing with the ideas generates questions and new ideas, not always realistic. At this time the question is following.

1. Could the Euclidian region associated with wormhole contact and connecting wormhole throats at the two sheets connect two disjoint, even distant regions of M^4? If so, the wormhole contact would be analogous to Einstein-Rosen bridge except that it has Euclidian signature of the induced metric.

   Could one identify the wormhole contact as a space-time correlate for entanglement or prerequisite for it? There would be no signal involved since in Euclidian space-time regions one cannot talk about propagation. Euclidian flux tubes are in central role in p-adic mass calculations [K64] but they are extremely short.

   I have assumed that time-like flux tubes can serve as correlates of entanglement. Could one can think that Minkowskian flux tubes would allow classical signalling and Euclidian flux tubes would serve as classical correlates for entanglement. Could both aspects be involved with quantum communications?

   Remark: One can obtain Euclidian space-time region from piece of M^4 by performing a large enough deformation in CP_2 directions and also this could give rise to Euclidian induced metric. One can also have cosmic string with piece of M^2 as string world sheet and deformed

such that one has flat E^2. The deformation of this string world sheet would represent Euclidian flux tube.

2. Here one must be however extremely cautious. Hitherto I have regarded shortness of flux tubes as obvious, and might have been right. One cannot however exclude the possibility that also Euclidian wormhole contacts are involved but they do not seem to be necessary: one could have wormhole magnetic fields with wormhole contacts only in the regions where M^4 projections overlap. All depends on the properties of preferred extremals.

5.8.5 How to understand the solar cycle?

Sunspot cycle (see `http://tinyurl.com/y2qlaaa2`) has period of 22 years and consists of two 11 year half-periods during which opposite polarity of B. The understanding of the mechanism causing the flip of the polarity looks the most difficult part of the problem - at least from TGD point of view. Each half cycle starts from a situation in which the dipole part of B vanishes and sunspots appear at opposite sides of equator at symmetrically related positions at mid-latitudes (about 30 degrees from equator).

Sunspots (see `http://tinyurl.com/y2qlaaa2`) carry intense magnetic fields (fields strength is about 2 Tesla in the vicinity of Sunspot according to Wikipedia) and they have lower temperature than surroundings due to the magnetic pressure. During the half-cycle Sunspots drift towards equator and maintain their polarity. The diagrammatic description of the time evolution at the solar surfaces is known as butterfly diagram. The natural interpretation is that the sunspots at opposite sides are connected by flux loops.

During the cycle the dipole field with opposite polarity as compared to previous cycle is generated and towards the end of the cycle there is a period in which no sun-spots are observed: they would be near equator if present. The spots could be present but the density of elementary flux tubes could be too low to give rise to average field strength enough to cause an observable reduction of temperature.

Polarity reversal of B

What could be behind polarity reversal. First some guiding ideas.

1. An analogy with ferromagnetic hysteresis circuit suggests itself. B generates B_1 having opposite direction. When the value of B_1 is critical it induces a phase transition in which the direction of Kähler flux is changed at flux tubes. Second half of the 22 year sunspot cycle would start. The ohmic current j generated by B would change and this would induce the magnetic turbulence accompanying solar spots.

   This analogy is not quite complete since the generation of B with opposite sign occurs slowly whereas the vanishing of magnetic field isa fast process. De-magnetizing phase transitions seems therefore a natural analog for the dis-appearance of B.

2. What the analog of spin flip means is highly non-trivial question when the size of the analog of spinning particle is of the size scale of Sun. Quantal and topological effect in solar scales could be in question and involve both TGD view about space-time and fields as well as hierarchy of Planck constants as description of dark matter. The model to be described in the sequel applies universally in TGD Universe and leads to quite dramatic and testable implications.

Consider next general TGD inspired ideas relating to the change of the polarity of B in TGD framework. A general model based on the formation of flux tube tangle as a representation of the say dipole field looks like a safe starting point and provides also a general model for the change of the polarity. An essential element is the distribution of incoming flux of long cosmic string like object to fluxes going through the interior and exterior of the dipole core and return back through exterior and interior. The fractions going through interior and exterior determine the strength of observed B. Whether both kinds of flux tubes are present or not, depends on model.

The first model, call it Model I, is classical. Now one could do using only single flux tube type, say type I, which however must divide to flux tubes travelling both inside and outside the dipole core.

1. The decay of B would correspond to option I involving the change of fractions p_1 and $p_2 = 1 - p_2$ of the flux tube portions going through the dipole core reducing the parameter $p_1 - p_2$ to zero. The permutations of flux tube portions inside and outside core must lead to $p_1 - p_2 = 0$ and one expects that this process continues and changes the sign of $p_1 - p_2$ and therefore induce polarization reversal. The duration of the process taking $p_1 - p_2$ to zero is rather short as compared to the duration of the half-cycle. The duration of the sunspot minimum is about 10 per cent of that for the entire half cycle. In the hydrodynamical analogy the process would be redistribution of the incoming flow and could be modelled phenomenologically as a change of flow resistances associated with the two channels involved.

2. This model does not involve reconnection process and does not provide any obvious explanation for the appearance of sunspots nor for the reconnection process associated with the reversal of the polarization of B. Therefore Model I is not promising.

Second model, call it Model II, is quantum mechanical and involves ZEO in an essential manner and one could assume that incoming flux tube enters to the dipole core entirely (option II).

1. Dipole winding number n_i characterizes the situation for a given type of flux tube. The larger the value of n_i, the larger the dipole strength. n_i could change by reconnection process in which entire dipole loop reconnects and snips away. This followed by further splitting to flux loops would correspond to the emission of magnetic loops from the Sun.

   The opposite process would correspond to a fusion of flux loop with a long flux loop but looks thermodynamically implausible. Also a fusion of a short flux loop with long flux loop and the growth of the reconnected part to large dipole loop looks implausible.

2. Could ZEO based quantum TGD allowing temporary time reversals come in rescue? At dark space-time sheets one can indeed imagine the possibility of time reversals. Ordinary matter would be controlled by dark matter with larger value of $h_{eff}/h_0 = n$ serving as an IQ in TGD inspired theory of consciousness, and would be forced to follow the leader in conflict with its thermodynamical instincts. Could the process involve "big" state function reduction (BSR) and could the dominance of flux tubes of type I and II correspond to different arrows of time at the level of dark flyx tubes? Reconnections for flux loops of say type II would occur in time direction opposite to the standard direction of time but second law would hold true in generalized sense.

3. The simplest option is that all incoming flux enters to the interior of the dipole core ($p_{2,I} = 0$ identically) or to its exterior ($p_{1,I} = 0$) identically. The first looks more plausible. The integers n_i, $i = \{I, II\}$ characterize the numbers of dipole flux loops carrying magnetic fields with opposite polarizations. Dipole strength is proportional to $n_I - n_{II}$. The arrows of time at the two sheets are assumed to be opposite for flux tube of type I and II.

4. Consider now a model for the first half-cycle.

   (a) Assume for definiteness that in the initial situation one has $(n_I = n_{max}, n_{II} = 0)$. B as maximum value B_{max}.

   (b) The transition leading $B = B_{max}$ to $B = 0$ would be "big" state function reduction (BSR) changing the arrow of time at sheets of both type I and II. BSR would generate maximum number of new dipole flux loops of type II: $n_{II} \to n_{max}$ so that one has $n_I = n_{II} = n_{max}$ and $B = 0$.

   This transition is clearly a quantum analog of spontaneous magnetization in sector II. Could one say that a spontaneous magnetization already present in sector I induces opposite spontaneous magnetization in sector II?

   Quantum classical correspondence (QCC) inspires the question about there is in the fermionic sector genuine spontaneous magnetization involving fermion spins. Could a formation cyclotron condensate of spin zero Cooper pairs with members at flux tubes of type I and II and having opposite spins accompany this process?

(c) After that dipole loops of type I begin to split away by reconnections in "small" state function reductions (SSRs) so that n_I decreases. They split further in pieces and leak out from Sun. Net B increases until one has $B = -B_{max}$. This process is analogous to gradual decay of magnetization.

(d) What looks strange that n_{II} would remains unchanged during this process. In ZEO this makes sense: it would corresponds to the passive boundary of causal diamond (CD). One would have two CDs having common portion of boundary, call it δCD. Since the arrows of time are opposite, $\delta CD \subset \delta CD_{II}$ would be passive and experience generalized Zeno effect whereas $\delta CD \subset \delta CD_I$ for CD_I would be active experiencing gradual decay of magnetization in the sequence of "small" state function reductions (SSRs).

(e) Topologically one can understand the sunspot cycle in terms of split dipole loops leaving the Sun: their intersection with the solar surface would define sunspot pair and the distance of members of the pair would decrease to zero during the cycle.

5. The model for the second half-cycle is identical. First occurs BSR generating maximum number of new flux loop portions of type I leading $n_I = n_{II} = n_{max}$ and $B = 0$ and same is repeated except that now n_{II} decreases.

The classically highly counter-intuitive aspect of this picture is that dipole loops would appear in BSR as quantum leap in astrophysical scales. There would be no continuous time evolution generating additional dipole loops. Their dis-appearance by reconnections would correspond to classical time evolution. If one performs time reversal for thermodynamic intuition, there is nothing mystical involved.

Model II looks to me more promising -if not even the only possibility - although conservative colleague can criticize it for the speculative new physics features: these features are however basic elements of new physics predicted by TGD.

Sunpots as intersections of split dipole flux loops with the Earth's surface?

How could sunspots be understood in the picture suggested by Model II?

1. BSR would induce the cancellation of B. Sunspots should emerge after the cancellation and serve as a signature of BSR inducing change of the arrow of time at flux tube space-time sheets. The usual statement is that the density of the elementary flux tubes composing the the split flux loop is high enough the average magnetic pressure lowers the temperature so much that the solar spot becomes visible.

Could the local reduction of temperature inside sunspots, something not expected in the naïve thermodynamical thinking be forced by the change of the arrow of time at dark flux tubes? One would have leveling of temperature differences but in opposite time direction induced by dark flux tubes having arrow of time opposite to the standard one: by dark flux tubes of type I during first half-cycle and flux tubes of type II during second half-cycle.

2. The appearance of sunspots would relate naturally to the reconnection process leading to the disappearance of the dipole loops Do the snipped flux loops, which can split further to pieces eventually leaving Sun, intersect its surface at the sunspots so that the formation of sunspot and its disappearance would correspond to a splitting of closed dipole loop by reconnection and further splitting to smaller loops.

The motion of sunspots towards equator would correspond to the outwards motion of the split flux dipole loop and solar spots would represent its intersection with solar surface. This also explains why the number of sunspots is gradually reduced during the half-cycle.

3. The fact that sunspots emerge first at latitudes $\pm\pi/6$ means that the split dipole flux loop intersects Earth's surface at positions with distance $h = R_E/2$ from equator. Since the distance is reduced after that, the outward motion of the loop requires that dipole core has height smaller than R_E.

Also in the case of Earth's magnetic field an analogous quantum picture might apply [L29] and solar spots might have "Earth spots" as magnetic anomalies. What is fascinating that the reversals of the Earth's magnetic field would be quantum processes in the scale of entire Earth and the magnetic field would go to zero instantaneously. What this means for living systems is an interesting question to ponder.

Does the polarity inversion involve spatial inversion?

Assume that the flux tubes correspond to monopole flux tube, which defines two-sheeted wormhole magnetic field. There is a strong temptation to assume that the members of the pairs defined by portions of flux tubes of given type (I or II) in the interior and exterior of dipole core are related by an approximate symmetry. If so, one would have doubles or mirror pairs of systems. What kind of symmetry polarity inversion for the solar B could correspond?

1. Assume that the two flux tube sheets of wormhole magnetic field have M^4 projections with empty intersection. Polarization reversal could permute the positions M^4 projections of the two sheets of flux tubes turning the direction of the magnetic flux. If the space-time surface representable as a map from CP_2 to M^4, the flip could be understood as a reflection in CP_2 degrees of freedom permuting the M^4 images and represented also as a reflection or inversion in M^4. In adelic physics [L50, L51] Z_2 has interpretation as subgroup of Galois group.

2. Could the solar magnetic field be doublet structure mapped to itself under Z_2? The identification of the pair as being formed by symmetry related parts of the flux dipole tubes in the interior of Sun and outside it is what comes naturally in mind. The symmetry could be realized as inversion with respect to the surface of Sun mapping inside and outside to each other. Inversions are indeed symmetries of Maxwell's theory, gauge theories, and of twistor Grassmannian approach. Also for $n_1 = 2m_1$ m_1 could correspond to a subgroup of CP_2. One would have double of bundles formed from m_1 flux tubes: dipole flux tuve consisting of m_1 elementary flux tubes.

3. The symmetry involved need not always be inversion. It could be also spatial reflection. The possibility of higher values of $n = n_1 n_2$, $n_1 = 2m_1$ suggests the possibility of long range correlations between m_1 pairs in astrophysical scales manifesting themselves quite concretely.

4. The representability of the group permuting flux tubes as finite discrete subgroups of $SO(3)$ acting as symmetries of Platonic solids would be very natural, and one can ask whether the appearance of Platonic solids in biology reflects this. This might allow to get some idea about why icosahedral model of harmony in terms of Hamiltonian cycles leading to the notion of bio-harmony predicts correctly genetic code [L19].

5.8.6 Trying to understand solar gamma ray spectrum in TGD Universe

One can try to understand the observations about gamma rays [E5, E4] (see `http://tinyurl.com/yxajyzp8` and `http://tinyurl.com/y2qlaaa2`) in the proposed picture. Some kind of acceleration mechanism suggests itself strongly.

1. An electric field associated with flux tubes with helical magnetic field is the simplest option. TGD allows simple deformations of flux tube like solutions [K59] in which Kähler magnetic and electric fields are orthogonal and helical and one can hope that they define preferred extremals.

   What about the electric force experienced by a test particle when the flux tubes of type I and II having same M^4 projection? The identification these objects in terms of dark energy would suggests that also the net electric force cancels and this kind of flux tube pair serves as a kind of superconducting wire.

2. If the flux tubes and gamma rays are dark with large $h_{eff}/h_0 = n = n_1 n_2$, they can propagate without interactions with ordinary matter. The dissipation would be solely due to curvature, in particular the kinks of the flux tube but would not be present at rectilinear portions of the flux tube. Therefore the amount of dissipation would be small.

Forgetting the losses caused by the curvature of the flux tube, there would be maximum energy $E = ZeV$, V the voltage along flux tube section to which the particles such as protons can be accelerated, and this would define cutoff energy for the emitted gamma rays. I have proposed that this kind of model explains also the gamma rays associated with lightnings [K26].

3. The dip in the spectrum suggests at least two energy scales for accelerated particles emitting gammas as brehmstrahlung and defining the endpoint of the brehmstrahlung spectrum. The explanation that comes in mind is that particles can go through several cycles of acceleration along closed dipole flux tubes and emit gamma rays at kinks. This would give rise to energy bands labelled by the number of acceleration cycle. The possibility of saturation looks plausible. One would have particle accelerator analogous to storage ring. What would be new as compared to LHC would be quantum coherence in the scale of accelerator. For the values of h_{eff} involved the dark particles would have Compton lengths of the order of the size of Sun.

4. How could the charged particle and gamma rays emerge from the flux tubes? One can start from everyday experience. Car can fall off the road in sharp curve. Now the sharp curve would correspond to a kink in flux tube. By momentum conservation there should be a large exchange of momentum with the flux tube to keep the charged particle at the flux tube and this is improbable for sharp kinks. Since the charged particles are relativistic and gamma rays must be directed to the observer, the change of momentum direction must be large. In any case, this requires a large exchange of momentum with the collective flux tubes degrees of freedom. It is quite possible that several gamma rays are emitted at the kink. The charged particle can also leak out.

   A proper description of the situation might be in terms of dark cyclotron states. If the TGD view about dark matter as $h_{eff}/h_0 = n = n_1 n_2$ phases is true on can treat the bundle of flux tubes as single quantum coherent entity. In particular, the solar spots could be identified as this kind of quantum coherent flux tube bundles and n_2 could correspond to the number of elementary flux tubes.

5. The sharp kinks appear at two places. Near the North pole where dipole field lines/flux tubes make a sharp kink. Due to differential rotation the flux tubes associated with the dipole contribution follow the rotation of equator and develop tentacles. The shape of strongly flattened square implies instability against splitting of the tentacles and decay to flux loops by reconnection. This part of the magnetic field decays and leads to magnetic turbulence. Also in the standard picture differential rotation is expected to induce reconnections of field lines. The kinks at the ends would induce emission of gammas and leakage of charged particles. Even single gamma ray could be enough.

   Gamma radiation indeed has two components. Polar component is roughly constant and the equatorial component having sharp maximum during sunspot minimum.

   Spectral index is different for the energy distributions for cosmic rays and gamma rays from Sun: solar distributions are harder. Also the equatorial distribution is harder than polar distribution. One expects that the distribution depends on the energy of the gamma ray and on the sharpness of the kink. In the case of polar distribution two gammas is minimum whereas for equatorial distribution single ray can be enough. This softens the polar distribution as compared to equatorial one. Since several loops are possible even the cosmic ray distribution for charged particles can harden.

   Where could the charged particles originate?

1. The basic observation is that flux of gammas is 5 times higher than predicted by the model identifying them as cosmic rays reflected in solar magnetic field fails. Roughly the same order of magnitude suggests that cosmic gamma rays could be the origin. Spectral distribution does not support this idea.

2. Charged particles could come from the solar core or along the long thickened cosmic string continuing as flux tubes of the magnetic field. Cosmic string would not accelerate the charged particles but only feed in the particles beams as kind of supra currents. Also cosmic rays

could enter the flux tubes as assumed in the original model: in fact, cosmic rays would naturally arrive along the long flux tubes connecting Sun to sources of cosmic rays.

This could explain why the upper bound for gamma ray energies for cosmic rays equals to the maximal detected energy (100 GeV). Instead of being reflected cosmic rays could rotate possibly several times around dipole flux tube and leak out in the kink. The emission of gamma rays at kinks reduces the energy gain for simple loop and for higher number of loops the reduction is larger. Saturation is quite possible.

3. The origin of galactic rays is still a mystery (see `http://tinyurl.com/psdp99h`). One proposal is that they originate from neutron stars. The proposed acceleration mechanism could be at work in the case of neutron stars so that neutron star could indeed provide the charged particles. As discussed there are also other options.

5.8.7 Surprises about the physics at the boundary of the heliosphere

I learned from interesting results about cosmic rays and behavior of magnetic field at the boundary of heliosphere (see the article "*Voyager Mission Reveals Unexpected Pressure at The Edge of The Solar System*" (see `http://tinyurl.com/y474zww4`). The article "*Pressure Runs High at Edge of Solar System*" (see `http://tinyurl.com/y5t258c8`) gives a more precise description of the findings.

There were two spacecrafts. Voyager2 was inside heliopause ad Voyager1 slightly outside it. They experienced different kind of reduction in cosmic ray flux. I picked up the following piece of text explaining the basic findings.

The scientists noted that the change in galactic cosmic rays wasn't exactly identical at both spacecraft. At Voyager 2 inside the heliosheath, the number of cosmic rays decreased in all directions around the spacecraft. But at Voyager 1, outside the solar system, only the galactic cosmic rays that were traveling perpendicular to the magnetic field in the region decreased. This asymmetry suggests that something happens as the wave transmits across the solar system's boundary.

Consider first TGD based view about magnetosphere of Sun.

1. TGD allows two kinds of magnetic fields: those for which flux tubes carry monopole flux and those for which they do not. Monopole flux tubes are impossible in Maxwellian world and solve several problems related to magnetic fields such as the existence of magnetic fields in cosmic scales, and the maintenance problem of the Earth's magnetic field [L29]

One of the latest applications is to the undertanding of the weird properties of the magnetic field of Mars identified in the model as consisting of monopole flux tubes [L80] and thus visible only through northern and southern lights involving reconnections of the monopole flux tubes. Also Mercury has unexpectely strong magnetic field and it could correspond to monopole flux tube tangle associated with flux tubes from Sun.

The latest application is to a model of earthquakes and volcanic eruptions [L81] known to be induced by cosmic rays but quite too deep for them to penetrate to the depths required. There is strong correlation with solar minima and it has turned out that the solar minimum corresponds to maximum of magnetic field. There is also a causal anomaly: electromagnetic fluctuations in upper atmosphere precede rather than follow these event. The new view about magnetic fields and zero energy ontology predicting that arrow of time changes in "big" (ordinary) state function reductions explains these anomalies. Causal anomalies involving change of also thermodynamical arrow of time are a generic signature of macroscopic state function reductions in TGD Universe.

2. Also a new view about cosmic rays emerges. Cosmic rays would travel along flux tubes of a gigantic fractal flux tube network defining analog of nervous system for the Universe [L90]. This picture leads to a rather detailed model for the formation of galaxies, stars and even planets as tangles along the flux tubes of this network having same topological structure as dipole magnetic field but with flux tubes carrying monopole flux [L72].

3. In TGD framework heliosphere corresponds to magnetically to U-shaped tentacles from Sun - flux tubes emanating from Sun radially and returning back to Sun and carrying solar wind and also cosmic rays. They look locally like parallel flux tubes carrying opposite magnetic fluxes. Flux tubes would extend to the heliopause and turn back and emit by reconnection narrow rectangle shaped closed flux tubes.By fractality these tentacles appear in all scales and are in crucial role in understanding of bio-catalysis and basic biochemical reactions like DNA replication, transcription of DNA to RNA, and translation of RNA to polypeptides.

4. Cosmic rays can travel as dark particles along them in TGD sense meaning that they would have effective Planck constant $h_{eff} = n \times h_0$, where h_0 is minimal value of h_{eff}. The flux tubes from Sun would thus bring dark particles along flux tubes. Suppose that the flux of cosmic rays arrive along these flux tubes, perhaps as dark particles.

Next one must translate various words to physical concepts in TGD framework.

1. Heliosheath (Voyager 2) is expected to be a turbulent boundary region. Magnetic turbulence means that the directions of U-shaped flux tubes coming from Sun are random. This is magnetic counterpart of a boiling liquid.

   Closed U-shaped flux tubes from Sun reach the heliopause before reconnection meaning emission of closed flux tubes looking like narrow rectangles travelling in radial direction: the direction of the flux is assumed to be along the radial flux tube and two directions are possible.

2. The region outside heliopause (Voyager 1) contains two kinds of monopole flux tubes, which need no current for their existence. Those of galactic magnetic field locally parallel to heliopause like in liquid flow around obstacle plus the closed flux tubes as outcomes of reconnection. They are assumed to be narrow rectangle-like objects in radial direction coming from the heliopause. There are also flux quanta of ordinary magnetic field generated by currents.

3. The wave called global merged interaction region (GMIR) caused by the activity of Sun means reconnections for the U-shaped flux tubes from the Sun at solar surface generating ordinary magnetic fields giving rise to sunspots. This reduces the number of U-shaped flux tubes and therefore also solar wind and the amount of cosmic rays arriving along them. Thus the reduction of solar wind and of cosmic rays both inside and outside heliosphere.

4. If the local directions of solar flux U-shaped tubes inside heliosheath are random by turbulence the reduction of flux takes place in all directions. It the long sides of closed flux tube rectangles are radial (orthogonal to the dominating galactic magnetic field), the reduction of flux takes place only in directions orthogonal to the galactic magnetic field. This was observed.

5. The high pressure could be due to the presence of closed flux tubes formed in reconnection and would represent the contribution of solar wind.

5.8.8 About general implications of the pairing hypothesis

If wormhole magnetic fields appear in all scales, flux tube pairs and more general $n_1 = 2m_1$ multiplets of flux tubes decomposing to m_2 pairs should be universal aspect of the dynamics of TGD Universe. In the following the implications are considered only briefly. The basic consequence is of course that Universe becomes in all scales a quantum coherent object and the locality hypothesis of classical physics would be simply wrong.

Elementary particle physics

Wormhole magnetic fields appear already in elementary particle physics. Elementary particles correspond to at least 2-sheeted flux tube structures with wormhole throats containing the boundaries of string world sheets carrying fundamental fermions. I have already earlier considered the possibility that the M^4 projections of the sheets are disjoint.

   Remark: In the general case one would have $n_1 = 2m_1$. Color symmetry for quarks could have as a remnant $m_1 = 3m_3$. For leptons m_1 would not be divisible by 3. Since n_1 corresponds to discrete subgroup for $SU(3)$, m_1 could correlate with the triality of $SU(3)$ partial wave defining the color quantum numbers of the particle.

Astrophysics and cosmology

The predictions in astrophysics and cosmology are in strong conflict with the locality principle of classical physics.

1. The model for magnetic spin flips in solar cycle leads to the conclusion that solar magnetic field could have doublet structure with parts related by inversion with respect to solar surface. Could the entire MB of Sun have copy somewhere. In principle this is an experimental question. The copy would be connected to Sun by wormhole magnetic flux tubes and this suggests long range correlations.

   Stars indeed very often appear as binaries (see `http://tinyurl.com/oooagma`). Could these pairs be related by approximate CP_2 symmetry inducing reflection of inversion in M^4? Could the planets of mirror paired stars be related by Z_2? Could there be correlations between the rotation planes for instance.

2. What about Earth could be invariant under inversion so that the radius of Earth could define the radius remaining invariant under inversion. This could make Earth so special as far as life is considered.

   Could Earth have a double in longer length scale? The least science fictive candidate would be another planet.

   Mars (see `http://tinyurl.com/mttm7h8`) has radius $.53R_E$, which is the radius that Earth would have had before the Cambrian Explosion according to TGD inspired variant of Expanding Earth model [L62]. Mass is 11 per cent of the Earth's mass. There are indications for life in Mars. Venus (see `http://tinyurl.com/72rz2g2`) has characteristics surprisingly near to those of Earth except that rotation is in opposite direction than for Earth: the rotation period is -243.025 days. The distances from Sun for (Venus,Earth,Mars) triplet are $(.72, 1.00, 1.52)$ AU. Could Venus and Mars form a mirror pair with respect to inversion at radius R_E.

   Recently Nasa found an exoplanet christened as Gliese 581d (see `http://tinyurl.com/yxdmpnbj` and `http://tinyurl.com/y2bwco6q`) located in constellation Lyra at distance of only 20.4 light years. The planet is almost exact copy of Earth as far the prerequisites of life are considered. Semimajor axis of the orbit is .22 from that of Earth. Mass is about 6.98 times higher than Earth mass, the radius is $2.20R_E$. The Sun of the planet could be mirror image of Earth: if this is the case, the should be correlations such as common rotation planes.

3. I have considered [L29] also a model for the changes of the orientation of Earth's magnetic field involving the interaction of monopole flux tubes and ordinary magnetic field via magnetic torques, and the solar model probably generalizes almost as such. Now however the orientation of the magnetic field can vary. This could relate to the fact that the axis of rotation differs from the magnetic axis. Again inversion as an approximate symmetry is suggestive.

4. The most intriguing finding about CMB spectrum is anomaly known as "Axis of Evil" (see `http://tinyurl.com/yb6nabw4`). The anomaly appears to give for the plane of planetary system of Sun and the location of Sun a greater significance that one might expect by change. This violates the Copernican Principle. The effect resembles selection of spin quantization axis in quantum measurement of spin performed by the measurer. A possible explanation at the level of space-time is that by $h_{eff}/h_0 = n$ hierarchy disjoint space-time sheets even in cosmic length scales are related by discrete CP_2 symmetries implying correlations.

Biology

The binary structures populating biology might correspond to pairs of monopole flux tubes. The original motivation for the proposal that they are important comes from p-adic length scale hypothesis: primes $p \simeq 2^{k+2}$ and $p \simeq 2^k$, where k and $k+2$ are twin primes, could define structures with size scale $L(k+2)$ decomposing to a pair of structures with size scale $L(k)$ [K27]. The structures of twin pair would form quantum entangled structures.

1. DNA and RNA double strands are basic examples of these structures. Even single DNA and RNA molecules form mirror pairs with their conjugates and could be connected by long wormhole contacts. This would make them quantum coherent structures making possible the mysterious ability of bio-molecules to find each other in the molecular crowd. Bio-systems would be extremely organized structure rather than a soup of randomly moving molecules. Could this kind of symmetries characterize all molecules that are paired or form higher structures with $n_1 = 2m_1$?

2. Cell membranes are formed by pair of lipid layers and also these could be twin pair. Epithelial sheets consist of two cell layers. At the level of body and brain there is also a pairing of subs-structures in left and right brain. Pineal gland is a connected structure could itself be a pair. Also brain hemispheres form a pair. Even married (or even non-married!) couple could form this kind of pair and what looks like a random personal relationship could be something much deeper.

3. All multi-molecular structures in living matter at least could correspond to groups of n_1 disjoint space-time sheets, perhaps magnetic flux tubes. The value of n_1 would serve as a measure for the scale of coherence and complexity.

4. Inversion corresponds to the inversion of the polarity of the Earth's magnetic field but might happen also at the cell level. In biology involution turning cell inside-out occurs during the gastrulation phase (see `http://tinyurl.com/y4pvpxyr`) of the embryonic development and leads to a development of 2 (ectoderm,endoterm) or 3 cell layers (ectoderm, mesoderm, endeterm) giving later rise to different types of tissues. This process looks rather mysterious - at least to me. Could involution be induced by the inversion of the magnetic body of the developing embryo?

5. MB controls (also our) biological body (BB) and uses scaled variants of EEG consisting of dark photons for this purpose [K44]. It is natural to assume that our MB corresponds to the part of MB above the Earth's surface. If Z_2 acts as inversion with respect to the surface of Earth then also the part of MB below the surface of Earth should correspond to an intentional agent.

   Could these MBs be associated intra-terrestrials ITs or could they control same BBs as our usual MBs? Here one must consider the precise definition of inversion: is it with respect to the surface of Earth or the boundary of the dipole core of the Earth's B? Taking inversion in the first sense of the definition very literally, one could argue that plants having also roots are inversion invariant but animals are strictly speaking not inversion invariant in either sense. Therefore we would have separate personal mirror MBs and also BBs: analogs of Dr. Jekyll and Mr. Hyde. In fact, I have have-jokingly considered a model for crop circles, and this led to a crazy idea about IT life [K41, K42]. Could this idea be not so crazy as it looks first? Accepting dark matter as $h_{eff}/h_0 = n$ phases, the high temperature in Earth interior ceases to be an objection.

6. $n_1 = 2m_1$ implies also that conscious entity can have n_1 disjoint pieces. They could be MBs controlling the same BB (multiple personality disorder) or maybe even separate BBs. Could these possibly distinct BBs locate at different sides of globe or even cosmos? What comes in mind Kieslowski's trilogy "Three colors". When the connection between hemispheres is destroyed, brain hemispheres controlling different body halves would live effectively separate lives, and could even fight for the control of BB. This gives some ideas as one tries to image what it is to have several BBs. It is interesting that in dreams we often have different identities than in wake-up state.

Consciousness

The existence of twin pairs might have profound implications for consciousness [L53, L64].

1. I proposed for about 2 decades ago what I called magnetospheric consciousness [K62, K60, K41, K42]. The MB of not only Earth but also our MB would have parts assignable to the interior and exterior of the Earth. Even the structures of brain should have a scaled up

MB image at both levels. The approximate inversion symmetry brings in exciting additional aspects. Maybe this division could provide the physical correlates for the Heaven-Hell dualism of religions and "as above-so below" dualism of perennial world views and mysticism.

2. Interior-exterior divisions are central for consciousness and the hierarchy of conscious entities in correspondence with the hierarchy of space-time sheets inspires the question whether also our biological bodies and environment could be related by an approximate symmetry at the level of MB at least so that one could speak of MBs assignable to the interior and exterior of BB. The sensory representations would reflect this approximate symmetry. Subsystem able to remain entangled at the passive boundary of CD defines the permanent part of self. But also its complement remains unentangled and should define permanent part of self: does this mean that the world outside me is a conscious entity?

3. One of the most dramatic predictions of TGD inspired theory of consciousness based on zero energy ontology (ZEO) is re-incarnation of self in death as a time-reversed self. There is indirect support for this: for instance, mental images identified as sub-selves die and re-incarnate and the period during which they are absent would correspond to the life with opposite arrow of time.

Where could these ghostly time-reversed re-incarnations live? Or putting it more formally: what regions of space-time surface do these entities control and receive sensory input from? Could inversion with respect to Earth's surface relate the space-time regions associated with self and its time reversal. If personal MB is part of MB above the Earth's surface, its inversion would be the part of MB below it. When we die we get buried. Could this ritual reflect the sub-conscious idea that our life continues as IT lifeform?

Chapter 6

Quantum Model for Bio-Superconductivity: I

6.1 Introduction

The model for EEG and its varints and nerve pulse relies on a general model of high T_c superconductivity [K25, K26]. In this chapter the general vision behind model of cell membrane as super-conductor inspired by the identification of dark matter in terms of hierarchy of Planck constants and the notion of magnetic body is discussed.

6.1.1 General Mechanism Of Bio-Superconductivity

The ideas about high temperature super-conductivity have evolved gradually as a reaction to experimental input and evelution in the understanding of TGD.

1. The many-sheeted space-time concept suggests a very general mechanism of superconductivity based on the "dropping" of charged particles from atomic space-time sheets to larger space-time sheets. The first guess was that larger space-time sheets are very dry, cool and silent so that the necessary conditions for the formation of high T_c macroscopic quantum phases are met. The criticism against this model is that particles topologically condensed to all space-time sheets having non-empty Minkowski space projection to the region where the particle is.

2. The possibility of large $\hbar$ quantum coherent phases makes the assumption about thermal isolation between space-time sheets un-necessary. At larger space-time sheet the interactions of the charged particles with classical em fields generated by various wormhole contacts feeding gauge fluxes to and from the space-time sheet in question give rise to the necessary gap energy. The simplest model for Cooper pair is space-time sheet containing charged particles having attractive Coulombic interaction with the quarks and antiquarks associated with the throats of the wormhole contacts.

3. It became clear quantum criticality predicting a new kind of superconductivity explaining the strange features of high T_c super-conductivity is essential. There are two kinds of Cooper pairs, exotic Cooper pairs and counterparts of ordinary BCS type Cooper pairs. Both correspond to a large value of Planck constant. Exotic Cooper pairs are quantum critical meaning that they can decay to ordinary electrons. Below temperature $T_{c_1} > T_c$ only exotic Cooper pairs with spin are present and their finite lifetime implies that super-conductivity is broken to ordinary conductivity satisfying scaling laws characteristic for criticality. At T_c spinless BCS type Cooper pairs become stable and exotic Cooper pairs can decay to them and vice versa. An open question is whether the BCS type Cooper pairs can be present also in the interior of cell.

   These two superconducting phases compete in certain narrow interval around critical temperature for which body temperature of endotherms is a good candidate in the case of living

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matter. Also high T_c superfluidity of bosonic atoms dropped to space-time sheets of electronic Cooper pairs becomes possible besides ionic super conductivity. Even dark neutrino superconductivity can be considered below the weak length scale of scaled down weak bosons.

4. Magnetic flux tubes would be carriers of dark particles and according to the findings about high temperature super-conductivity magnetic fields are indeed crucial for super-conductivity. Two parallel flux tubes carrying magnetic fluxes in opposite directions is the simplest candidate for super-conducting system. This conforms with the observation that antiferromagnetism is somehow crucial for high temperature super-conductivity. The spin interaction energy is proportional to Planck constant and can be above thermal energy: if the hypothesis that dark cyclotron energy spectrum is universal is accepted, then the energies would be in bio-photon range and high temperature super-conductivity is obtained. If fluxes are parallel spin $S = 1$ Cooper pairs are stable. $L = 2$ states are in question since the members of the pair are at different flux tubes. These two kinds of Cooper pairs could correspond to BCS type and exotic Cooper pairs.

   The fact that the critical magnetic fields can be very weak or large values of $\hbar$ is in accordance with the idea that various almost topological quantum numbers characterizing induced magnetic fields provide a storage mechanism of bio-information.

   This mechanism is extremely general and in principle works for electrons, protons, ions, charged molecules and even exotic neutrinos and an entire zoo of high T_c bio-superconductors, super-fluids and Bose-Einstein condensates is predicted. Of course, there are restrictions due to the thermal stability it room temperature and it seems that only electron, neutrino, and proton Cooper pairs are possible at room temperature besides Bose-Einstein condensates of all bosonic ions and their exotic counterparts resulting when some nuclear color bonds become charged.

5. This mechanism of high temperature super-conductivity is extremely general and in principle works for electrons, protons, ions, charged molecules and even exotic neutrinos and an entire zoo of high T_c bio-superconductors, super-fluids and Bose-Einstein condensates is predicted. Of course, there are restrictions due to the thermal stability it room temperature. If h_{eff} is proportional to the particle mass, the binding energy of Cooper pairs identifiable as spin-spin interaction energy and does not depend on the mass of the Cooper pair. The bindng energy is proportional to h_{eff} and in visible and UV range if bio-photons result when dark photon transforms to ordinary photon. The hypothesis that gravitational Planck constant and h_{eff} are identical ($h_{eff} = h_{gr}$) in microscopic domain, implies the universality.

6.1.2 Hierarchies Of Preferred P-Adic Length Scales And Values Of Planck Constant

All p-adic length scales above electron length scale $L_e(127)$ were identified erratically in all writings about TGD before 2014. This deserves some clarifying comments.

1. The wrong identification was $L(151) \simeq 10$ nm implying wrong identification of other scales above $L(127)$ since I have calculated them by scaling $L(151)$ by an appropriate power of two. What I have denoted by $L(151)$ is actually obtained by scaling the Compton length $L_e(127) = \hbar/m_e$ by $2^{(151-127)/2}$ and therefore electrons Compton scale if it would correspond to $k = 151$. Since the mass of electron from p-adic mass calculations is given by $m_e = \sqrt{5 + X}\hbar/L(127)$, the correct identification of $L(151)$ would be

$$L(151) = 2^{(151-127)/2}L(127) = 2^{(151-127)/2}L_e(151)/\sqrt{5 + X} = 10/\sqrt{5 + X} \ nm \ , \ 0 \leq X \leq 1 \ .$$

   Here X denotes the unknown second order contribution of form $X = n/M_{127}$, n integer, to the electron mass, and in the first approximation one can take $X = 0$ - the approximation is excellent unless n is very large. In the sequel I will try to use the shorthand $L_e(k) = \sqrt{5}L(k)$ but cannot guarantee that the subscript "e" is always present when needed: it is rather difficult to identify all places where the earlier erratic definition appears. I can only apologise for possible confusions.

2. This mistake has no fatal consequences for TGD inspired quantum biology. Its detection however provides a further support for the speculated central role of electron in living matter. Since the scales obtained by scaling the electron Compton scale seem to be important biologically (scaled up Comton scale $\sqrt{5}L(151)$ corresponds to cell membrane thickness), the conclusion is that electrons - or perhaps their Cooper pairs - play a fundamental role in living matter. The correct value of $L(151)$ is $L(151) = 4.5$ nm, which is slightly below the p-adic length scale $L_e(149) = 5$ nm assigned with the lipid layer of cell membrane.

3. I have also assigned to electron the time scale $T = .1$ seconds defining a fundamental biorhythm as a secondary p-adic time scale $T_2(127) = \sqrt{M_{127}}T(127)$. The correct assignment of $T = .1$ seconds is as the secondary Compton time $T_{2,e}(127) = \sqrt{M_{127}}T_e(127)$ of electron: secondary p-adic time scale is $T_2(127) = \sqrt{M_{127}}T(127)$ and corresponds to $T_{2,e}(127)/\sqrt{5} = .045$ seconds and to $f(127) = 22.4$ Hz.

TGD inspired quantum biology and number theoretical considerations suggest preferred values for $r = \hbar/\hbar_0$. For the most general option the values of $\hbar$ are products and ratios of two integers n_a and n_b. Ruler and compass integers defined by the products of distinct Fermat primes and power of two are number theoretically favored values for these integers because the phases $exp(i2\pi/n_i)$, $i \in \{a, b\}$, in this case are number theoretically very simple and should have emerged first in the number theoretical evolution via algebraic extensions of p-adics and of rationals. p-Adic length scale hypothesis favors powers of two as values of r.

The hypothesis that Mersenne primes $M_k = 2^k - 1$, $k \in \{89, 107, 127\}$, and Gaussian Mersennes $M_{G,k} = (1 + i)k - 1$, $k \in \{113, 151, 157, 163, 167, 239, 241..\}$ (the number theoretical miracle is that all the four scale up Compton lengths of electron with $k \in \{151, 157, 163, 167\}$ are in the biologically highly interesting range 10 nm-2.5 μm) define scaled up copies of electro-weak and QCD type physics with ordinary value of $\hbar$ and that these physics are induced by dark variants of corresponding lower level physics leads to a prediction for the preferred values of $r = 2^{k_d}$, $k_d = k_i - k_j$, and the resulting picture finds support from the ensuing models for biological evolution and for EEG [K44]. This hypothesis - to be referred to as Mersenne hypothesis - replaces the earlier rather ad hoc proposal $r = \hbar/\hbar_0 = 2^{11k}$ for the preferred values of Planck constant.

6.1.3 Fractal Hierarchy Of Magnetic Flux Sheets And The Hierarchy Of Genomes

The notion of magnetic body is central in the TGD inspired theory of living matter. Every system possesses magnetic body and there are strong reasons to believe that the magnetic body associated with human body is of order Earth size and that there could be an entire hierarchy of these bodies with even much larger sizes. Therefore the question arises what one can assume about these magnetic bodies. The quantization of magnetic flux suggests an answer to this question.

1. The quantization condition for magnetic flux reads in the most general form as $\oint (p - eA) \cdot dl = n\hbar$. If supra currents flowing at the boundaries of the flux tube are absent one obtains $e \int B \cdot dS = n\hbar$, which requires that the scaling of the Planck constant scales up the flux tube thickness by r^2 and scaling of B by $1/r$. If one assumes that the radii of flux tubes do not depend on the value of r, magnetic flux is compensated by the contribution of the supra current flowing around the flux tube: $\oint (p - eA) \cdot dl = 0$. The supra currents would be present inside living organism but in the faraway region where flux quanta from organism fuse together, the quantization conditions $e \int B \cdot dS = n\hbar$ would be satisfied.

2. From the point of view of EEG especially interesting are the flux sheets which have thickness $L = 10$ nm (the thickness of cell membrane) carrying magnetic field having strength of endogenous magnetic field. $L = 10$ nm corresponds to p-adically scaled electron Compton length $L_e(151)$. In absence of supra currents these flux sheets have very large total transversal length proportional to r^2. The condition that the values of cyclctron energies are above thermal energy implies that the value of r is of order 2^{k_d}, $k_d = 44$. Strongly folded flux sheets of this thickness might be associated with living matter and connect their DNAs to single coherent structure. One can of course assume the presence of supra currents but outside the organism the flux sheet should fuse to form very long flux sheets.

3. Suppose that the magnetic flux flows in head to tail direction so that the magnetic flux arrives to the human body through a layer of cortical neurons. Assume that the flux sheets traverse through the uppermost layer of neurons and also lower layers and that DNA of each neuronal nuclei define a transversal sections organized along flux sheet like text lines of a book page. The total length of DNA in single human cell is about one meter. It seems that single organism cannot provide the needed total length of DNA if DNA dominates the contribution. This if of course not at all necessarily since supra currents are possible and outside the organism the flux sheets can fuse together. This implies however correlations between genomes of different cells and even different organisms.

These observations inspire the notion of super- and hyper genes. As a matter fact, entire hierarchy of genomes is predicted. Super genes consist of genes in different cell nuclei arranged to threads along magnetic flux sheets like text lines on the page of book whereas hyper genes traverse through genomes of different organisms. Super and hyper genes provide an enormous representative capacity and together with the dark matter hierarchy allows to resolve the paradox created by the observation that human genome does not differ appreciably in size from that of wheat.

6.1.4 Bose-Einstein Condensates At Magnetic Flux Quanta In Astrophysical Length Scales

The model for the topological condensation at magnetic flux quanta of endogenous magnetic field $B_{end} = .2$ Gauss is based on the dark matter hierarchy with levels characterized by the values of Planck constant. The hypothesis for the preferred values of Planck constans allows to build quantitative model for the Bose-Einstein condensation at magnetic flux quanta assuming that the value of B_{end} scales like $1/\hbar$. A justification for this hypothesis comes form flux quantization conditions and from the similar scaling of Josephson frequencies [K44].

1. There are several levels of dynamics. In topological condensation the internal dynamics of ions is unaffected and $\hbar$ has the ordinary value. For instance, the formation of Cooper pairs involves dynamics at $k_d = 24 = 151 - 127$ level of dark matter hierarchy if one assumes that electrons and Cooper pairs have size given by the cell membrane thickess equal to $L_e(151)$. Also the dynamics of ionic Cooper pairs remains unaffected in the topological condensation to magnetic flux quanta obeying $k_d > 24$ dynamics.

2. Cyclotron energies scale as as $\hbar$ so that for a sufficiently high value of k_d thermal stability of cyclotron states at room temperature is achieved for a fixed value of B. Same applies to spin flip transitions in the recent scenario. The model for EEG based on dark matter hierarchy [K44] involves the hypothesis that EEG quanta correspond to Josephson radiation with energies in the visible and UV range and that they produce in the decay to ordinary photons either bunches of EEG photons or visible/UV photons. This identification allows to deduce the value of k_d when the frequency of the dark photon is fixed. The Mersenne hypothesis for the preferred p-adic length scales and values of Planck constants leads to very precise predictions.

3. Cyclotron energies $E = (\hbar/2\pi) \times ZeB/Am_p$ are scaled up by a factor $r = 2^{k_d}$ from their ordinary values and for 10 Hz cyclotron frequency are in the range of energies of visible light for $k_d = 46$.

The appendix of the book gives a summary about basic concepts of TGD with illustrations. Pdf representation of same files serving as a kind of glossary can be found at `http://tgdtheory.fi/tgdglossary.pdf` [L18].

6.2   General TGD Based View About Super-Conductivity

Today super-conductivity includes besides the traditional low temperature super-conductors many other non-orthodox ones [D59]. These unorthodox super-conductors carry various attributes such as cuprate, organic, dichalcogenide, heavy fermion, bismute oxide, ruthenate, antiferromagnetic

and ferromagnetic. Mario Rabinowitz has proposed a simple phenomenological theory of super-fluidity and super-conductivity which helps non-specialist to get a rough quantitative overall view about super-conductivity [D59].

6.2.1 Basic Phenomenology Of Super-Conductivity

The following provides the first attempt by a non-professional to form an overall view about super-conductivity.

Basic phenomenology of super-conductivity

The transition to super-conductivity occurs at critical temperature T_c and involves a complete loss of electrical resistance. Super-conductors expel magnetic fields (Meissner effect) and when the external magnetic field exceeds a critical value H_c super-conductivity is lost either completely or partially. In the transition to super-conductivity specific heat has singularity. For long time magnetism and super-conductivity were regarded as mutually exclusive phenomena but the discovery of ferromagnetic super-conductors [D45, D15] has demonstrated that reality is much more subtle.

The BCS theory developed by Bardeen, Cooper, and Schrieffer in 1957 provides a satisfactory model for low T_c super-conductivity in terms of Cooper pairs. The interactions of electrons with the crystal lattice induce electron-electron interaction binding electrons to Cooper pairs at sufficiently low temperatures. The electrons of Cooper pair are at the top of Fermi sphere (otherwise they cannot interact to form bound states) and have opposite center of mass momenta and spins. The binding creates energy gap E_g determining the critical temperature T_c. The singularity of the specific heat in the transition to super-conductivity can be understood as being due to the loss of thermally excitable degrees of freedom at critical temperature so that heat capacity is reduced exponentially. BCS theory has been successful in explaining the properties of low temperature super conductors but the high temperature super-conductors discovered in 1986 and other non-orthodox superconductors discovered later remain a challenge for theorists.

The reasons why magnetic fields tend to destroy super-conductivity is easy to understand. Lorentz force induces opposite forces to the electrons of Cooper pair since the momenta are opposite. Magnetic field tends also to turn the spins in the same direction. The super-conductivity is destroyed in fields for which the interaction energy of magnetic moment of electron with field is of the same order of magnitude as gap energy $E_g \sim T_c$: $e\hbar H_c/2m \sim T_c$.

If spins are parallel, the situation changes since only Lorentz force tends to destroy the Cooper pair. In high T_c super-conductors this is indeed the case: electrons are in spin triplet state ($S = 1$) and the net orbital angular momentum of Cooper pair is $L = 2$. The fact that orbital state is not $L = 0$ state makes high T_c super-conductors much more fragile to the destructive effect of impurities than conventional super-conductors (due to the magnetic exchange force between electrons responsible for magnetism). Also the Cooper pairs of ^3He superfluid are in spin triplet state but have $S = 0$.

The observation that spin triplet Cooper pairs might be possible in ferro-magnets stimulates the question whether ferromagnetism and super-conductivity might tolerate each other after all, and the answer is affirmative [D15]. The article [D45] provides an enjoyable summary of experimental discoveries.

Basic parameters of super-conductors from universality?

Super conductors are characterized by certain basic parameters such as critical temperature T_c and critical magnetic field H_c, densities n_c and n of Cooper pairs and conduction electrons, gap energy E_g, correlation length ξ and magnetic penetration length λ. The super-conductors are highly complex systems and calculation of these parameters from BCS theory is either difficult or impossible.

It has been suggested [D59] that these parameters might be more or less universal so that they would not depend on the specific properties of the interaction responsible for the formation of Cooper pairs. The motivation comes from the fact that the properties of ordinary Bose-Einstein condensates do not depend on the details of interactions. This raises the hope that these parameters might be expressible in terms of some basic parameters such as T_c and the density of conduction

electrons allowing to deduce Fermi energy E_F and Fermi momentum k_F if Fermi surface is sphere. In [D59] formulas for the basic parameters are indeed suggested based on this of argumentation assuming that Cooper pairs form a Bose-Einstein condensate.

1. The most important parameters are critical temperature T_c and critical magnetic field H_c in principle expressible in terms of gap energy. In [D59] the expression for T_c is deduced from the condition that the de Broglie wavelength λ must satisfy in supra phase the condition

$$\lambda \geq 2d = 2(\frac{n_c}{g})^{-1/D} \tag{6.2.1}$$

guaranteeing the quantum overlap of Cooper pairs. Here n_c is the density of Bose-Einstein condensate of Cooper pairs and g is the number of spin states and D the dimension of the condensate. This condition follows also from the requirement that the number of particles per energy level is larger than one (Bose-Einstein condensation).

Identifying this expression with the de Broglie wavelength $\lambda = \hbar/\sqrt{2mE}$ at thermal energy $E = (D/2)T_c$, where D is the number of degrees of freedom, one obtains

$$T_c \quad \leq \quad \frac{h^2}{4Dm}(\frac{n_c}{g})^{2/D} \quad . \tag{6.2.2}$$

m denotes the effective mass of super current carrier and for electron it can be even 100 times the bare mass of electron. The reason is that the electron moves is somewhat like a person trying to move in a dense crowd of people, and is accompanied by a cloud of charge carriers increasing its effective inertia. In this equation one can consider the possibility that Planck constant is not the ordinary one. This obviously increases the critical temperature unless n_c is scaled down in same proportion in the phase transition to large $\hbar$ phase.

2. The density of n_c Cooper pairs can be estimated as the number of fermions in Fermi shell at E_F having width Δk deducible from kT_c. For $D = 3$-dimensional spherical Fermi surface one has

$$n_c \quad = \quad \frac{1}{2}\frac{4\pi k_F^2 \Delta k}{\frac{4}{3}\pi k_F^3}n \quad ,$$

$$kT_c \quad = \quad E_F - E(k_F - \Delta k) \simeq \frac{h^2 k_F \Delta k}{m} \quad . \tag{6.2.3}$$

Analogous expressions can be deduced in $D = 2$- and $D = 1$-dimensional cases and one has

$$n_c(D) \quad = \quad \frac{D}{2}\frac{T_c}{E_F}n(D) \quad . \tag{6.2.4}$$

The dimensionless coefficient is expressible solely in terms of n and effective mass m. In [D59] it is demonstrated that the inequality 6.2.2 replaced with equality when combined with 6.2.4 gives a satisfactory fit for 16 super-conductors used as a sample.

Note that the Planck constant appearing in E_F and T_c in Eq. 6.2.4 must correspond to ordinary Planck constant $\hbar_0$. This implies that equations 6.2.2 and 6.2.4 are consistent within orders of magnitudes. For $D = 2$, which corresponds to high T_c superconductivity, the substitution of n_c from Eq. 6.2.4 to Eq. 6.2.2 gives a consistency condition from which n_c disappears completely. The condition reads as

$$n\lambda_F^2 = \pi = 4g \quad .$$

Obviously the equation is not completely consistent.

3. The magnetic penetration length λ is expressible in terms of density n_c of Cooper pairs as

$$\lambda^{-2} = \frac{4\pi e^2 n_c}{m_e} \quad . \tag{6.2.5}$$

The ratio $\kappa \equiv \frac{\lambda}{\xi}$ determines the type of the super conductor. For $\kappa < \frac{1}{\sqrt{2}}$ one has type I super conductor with defects having negative surface energy. For $\kappa \geq \frac{1}{\sqrt{2}}$ one has type II super conductor and defects have positive surface energy. Super-conductors of type I this results in complex stripe like flux patterns maximizing their area near criticality. The super-conductors of type II have $\kappa > 1/\sqrt{2}$ and the surface energy is positive so that the flux penetrates as flux quanta minimizing their area at lower critical value H_{c_1} of magnetic field and completely at higher critical value H_{c_2} of magnetic field. The flux quanta contain a core of size ξ carrying quantized magnetic flux.

4. Quantum coherence length ξ can be roughly interpreted as the size of the Cooper pair or as the size of the region where it is sensible to speak about the phase of wave function of Cooper pair. For larger separations the phases of wave functions are un-correlated. The values of ξ vary in the range $10^3 - 10^4$ Angstrom for low T_c super-conductors and in the range $5 - 20$ Angstrom for high T_c super-conductors (assuming that they correspond to ordinary $\hbar$!) the ratio of these coherence lengths varies in the range $[50 - 2000]$, with upper bound corresponding to $n_F = 2^{11}$ for $\hbar$. This would give range $1 - 2$ microns for the coherence lengths of high T_c super-conductors with lowest values of coherence lengths corresponding to the highest values of coherence lengths for low temperatures super conductors.

Uncertainty Principle $\delta E \delta t = \hbar/2$ using $\delta E = E_g \equiv 2\Delta$, $\delta t = \xi/v_F$, gives an order of magnitude estimate for ξ differing only by a numerical factor from the result of a rigorous calculation given by

$$\xi \quad = \quad \frac{4\hbar v_F}{E_g} \quad . \tag{6.2.6}$$

E_g is apart from a numerical constant equal to T_c: $E_g = nT_c$. Using the expression for v_F and T_c in terms of the density of electrons, one can express also ξ in terms of density of electrons.

For instance, BCS theory predicts $n = 3.52$ for metallic super-conductors and $n = 8$ holds true for cuprates [D59]. For cuprates one obtains $\xi = 2n^{-1/3}$ [D59]. This expression can be criticized since cuprates are Mott insulators and it is not at all clear whether a description as Fermi gas makes sense. The fact that high T_c super-conductivity involves breakdown of anti-ferromagnetic order might justify the use of Fermi gas description for conducting holes resulting in the doping.

For large $\hbar$ the value of ξ would scale up dramatically if deduced theoretically from experimental data using this kind of expression. If the estimates for ξ are deduced from v_F and T_c purely calculationally as seems to be the case, the actual coherence lengths would be scaled up by a factor $\hbar/\hbar_0 = n_F$ if high T_c super-conductors correspond to large $\hbar$ phase. As also found that this would also allow to understand the high critical temperature.

6.2.2   Universality Of The Parameters In TGD Framework

Universality idea conforms with quantum criticality of TGD Universe. The possibility to express everything in terms of density of critical temperature coding for the dynamics of Cooper pair formation and the density charge carriers would make it also easy to understand how p-adic scalings and transitions to large $\hbar$ phase affect the basic parameters. The possible problem is that the replacement of inequality of Eq. 6.2.2 with equality need not be sensible for large $\hbar$ phases. It will be found that in many-sheeted space-time T_c does not directly correspond to the gap energy and the universality of the critical temperature follows from the p-adic length scale hypothesis.

The effect of p-adic scaling on the parameters of super-conductors

p-Adic fractality expresses as $n \propto 1/L^3(k)$ would allow to deduce the behavior of the various parameters as function of the p-adic length scale and naïve scaling laws would result. For instance, E_g and T_c would scale as $1/L^2(k)$ if one assumes that the density n of particles at larger space-time sheets scales p-adically as $1/L^3(k)$. The basic implication would be that the density of Cooper pairs and thus also T_c would be reduced very rapidly as a function of the p-adic length scale. Without thermal isolation between these space-time sheets and hight temperature space-time sheets there would not be much hopes about high T_c super-conductivity.

In the scaling of Planck constant basic length scales scale up and the overlap criterion for super-conductivity becomes easy to satisfy unless the density of electrons is reduced too dramatically. As found, also the critical temperature scales up so that there are excellent hopes of obtain high T_c super-conductor in this manner. The claimed short correlation lengths are not a problem since they are calculational quantities.

It is of interest to study the behavior of the various parameters in the transition to the possibly existing large $\hbar$ variant of super-conducting electrons. Also small scalings of $\hbar$ are possible and the considerations to follow generalize trivially to this case. Under what conditions the behavior of the various parameters in the transition to large $\hbar$ phase is dictated by simple scaling laws?

1. Scaling of T_c and E_g

T_c and E_g remain invariant if E_g corresponds to a purely classical interaction energy remaining invariant under the scaling of $\hbar$. This is not the case for BCS super-conductors for which the gap energy E_g has the following expression.

$$
\begin{aligned}
E_g &= \hbar \omega_c exp(-1/X) \ , \\
X &= n(E_F)U_0 = \frac{3}{2} N(E_F) \frac{U_0}{E_F} \ , \\
n(E_F) &= \frac{3}{2} \frac{N(E_F)}{E_F} \ . \\
\omega_c &= \omega_D = (6\pi^2)^{1/3} c_s n_n^{1/3} \ .
\end{aligned}
\tag{6.2.7}
$$

Here ω_c is the width of energy region near E_F for which "phonon" exchange interaction is effective. n_n denotes the density of nuclei and c_s denotes sound velocity.

$N(E_F)$ is the total number of electrons at the super-conducting space-time sheet. U_0 would be the parameter characterizing the interaction strength of of electrons of Cooper pair and should not depend on $\hbar$. For a structure of size $L \sim 1 \ \mu$ m one would have $X \sim n_a 10^{12} \frac{U_0}{E_F}$, n_a being the number of exotic electrons per atom, so that rather weak interaction energy U_0 can give rise to $E_g \sim \omega_c$.

The expression of ω_c reduces to Debye frequency ω_D in BCS theory of ordinary super conductivity. If c_s is proportional to thermal velocity $\sqrt{T_c/m}$ at criticality and if n_n remains invariant in the scaling of $\hbar$, Debye energy scales up as $\hbar$. This can imply that $E_g > E_F$ condition making scaling non-sensible unless one has $E_g \ll E_F$ holding true for low T_c super-conductors. This kind of situation would *not* require large $\hbar$ phase for electrons. What would be needed that nuclei and phonon space-time sheets correspond to large $\hbar$ phase.

What one can hope is that E_g scales as $\hbar$ so that high T_c superconductor would result and the scaled up T_c would be above room temperature for $T_c > .15$ K. If electron is in ordinary phase X is automatically invariant in the scaling of $\hbar$. If not, the invariance reduces to the invariance of U_0 and E_F under the scaling of $\hbar$. If n scales like $1/\hbar^D$, E_F and thus X remain invariant. U_0 as a simplified parameterization for the interaction potential expressible as a tree level Feynman diagram is expected to be in a good approximation independent of $\hbar$.

It will be found that in high T_c super-conductors, which seem to be quantum critical, a high T_c variant of phonon mediated superconductivity and exotic superconductivity could be competing. This would suggest that the phonon mediated superconductivity corresponds to a large $\hbar$ phase for nuclei scaling ω_D and T_c by a factor $r = \hbar/\hbar_0$.

Since the total number $N(E_F)$ of electrons at larger space-time sheet behaves as $N(E_F) \propto E_F^{D/2}$, where D is the effective dimension of the system, the quantity $1/X \propto E_F/n(E_F)$ appearing

in the expressions of the gap energy behaves as $1/X \propto E_F^{-D/2+1}$. This means that at the limit of vanishing electron density $D = 3$ gap energy goes exponentially to zero, for $D = 2$ it is constant, and for $D = 1$ it goes zero at the limit of small electron number so that the formula for gap energy reduces to $E_g \simeq \omega_c$. These observations suggests that the super-conductivity in question should be 2- or 1-dimensional phenomenon as in case of magnetic walls and flux tubes.

2. Scaling of ξ and λ

If n_c for high T_c super-conductor scales as $1/\hbar^D$ one would have $\lambda \propto \hbar^{D/2}$. High T_c property however suggests that the scaling is weaker. ξ would scale as $\hbar$ for given v_F and T_c. For $D = 2$ case the this would suggest that high T_c super-conductors are of type I rather than type II as they would be for ordinary $\hbar$. This conforms with the quantum criticality which would be counterpart of critical behavior of super-conductors of type I in nearly critical magnetic field.

3. Scaling of H_c and B

The critical magnetization is given by

$$H_c(T) \quad = \quad \frac{\Phi_0}{\sqrt{8}\pi\xi(T)\lambda(T)} \quad , \tag{6.2.8}$$

where Φ_0 is the flux quantum of magnetic field proportional to $\hbar$. For $D = 2$ and $n_c \propto \hbar^{-2}$ $H_c(T)$ would not depend on the value of $\hbar$. For the more physical dependence $n_c \propto \hbar^{-2+\epsilon}$ one would have $H_c(T) \propto \hbar^{-\epsilon}$. Hence the strength of the critical magnetization would be reduced by a factor $2^{-11\epsilon}$ in the transition to the large $\hbar$ phase with $n_F = 2^{-11}$.

Magnetic flux quantization condition is replaced by

$$\int 2eBdS = n\hbar 2\pi \quad . \tag{6.2.9}$$

B denotes the magnetic field inside super-conductor different from its value outside the super-conductor. By the quantization of flux for the non-super-conducting core of radius ξ in the case of super-conductors of type II $eB = \hbar/\xi^2$ holds true so that B would become very strong since the thickness of flux tube would remain unchanged in the scaling.

6.2.3   Quantum Criticality And Super-Conductivity

The notion of quantum criticality has been already discussed in introduction. An interesting prediction of the quantum criticality of entire Universe also gives naturally rise to a hierarchy of macroscopic quantum phases since the quantum fluctuations at criticality at a given level can give rise to higher level macroscopic quantum phases at the next level. A metaphor for this is a fractal cusp catastrophe for which the lines corresponding to the boundaries of cusp region reveal new cusp catastrophes corresponding to quantum critical systems characterized by an increasing length scale of quantum fluctuations.

Dark matter hierarchy could correspond to this kind of hierarchy of phases and long ranged quantum slow fluctuations would correspond to space-time sheets with increasing values of $\hbar$ and size. Evolution as the emergence of modules from which higher structures serving as modules at the next level would correspond to this hierarchy. Mandelbrot fractal with inversion analogous to a transformation permuting the interior and exterior of sphere with zooming revealing new worlds in Mandelbrot fractal replaced with its inverse would be a good metaphor for what quantum criticality would mean in TGD framework.

How the quantum criticality of superconductors relates to TGD quantum criticality

There is empirical support that super-conductivity in high T_c super-conductors and ferromagnetic systems [D45, D30] is made possible by quantum criticality [D69]. In the experimental situation quantum criticality means that at sufficiently low temperatures quantum rather than thermal fluctuations are able to induce phase transitions. Quantum criticality manifests itself as fractality and simple scaling laws for various physical observables like resistance in a finite temperature range

and also above the critical temperature. This distinguishes sharply between quantum critical super conductivity from BCS type super-conductivity. Quantum critical super-conductivity also exists in a finite temperature range and involves the competition between two phases.

The absolute quantum criticality of the TGD Universe maps to the quantum criticality of subsystems, which is broken by finite temperature effects bringing dissipation and freezing of quantum fluctuations above length and time scales determined by the temperature so that scaling laws hold true only in a finite temperature range.

Reader has probably already asked what quantum criticality precisely means. What are the phases which compete? An interesting hypothesis is that quantum criticality actually corresponds to criticality with respect to the phase transition changing the value of Planck constant so that the competing phases would correspond to different values of $\hbar$. In the case of high T_c super-conductors (anti-ferromagnets) the fluctuations can be assigned to the magnetic flux tubes of the dipole field patterns generated by rows of holes with same spin direction assignable to the stripes. Below T_c fluctuations induce reconnections of the flux tubes and a formation of very long flux tubes and make possible for the supra currents to flow in long length scales below T_c. Percolation type phenomenon is in question. The fluctuations of the flux tubes below $T_{c1} > T_c$ induce transversal phonons generating the energy gap for $S = 1$ Cooper pairs. $S = 0$ Cooper pairs are predicted to stabilize below T_c.

Scaling up of de Broglie wave lengths and criterion for quantum overlap

Compton lengths and de Broglie wavelengths are scaled up by an integer n, whose preferred values correspond to $n_F = 2^k \prod_s F_s$, where $F_s = 2^{2^s} + 1$ are distinct Fermat primes. In particular, $n_F = 2^{k11}$ seem to be favored in living matter. The scaling up means that the overlap condition $\lambda \geq 2d$ for the formation of Bose-Einstein condensate can be satisfied and the formation of Cooper pairs becomes possible. Thus a hierarchy of large $\hbar$ super-conductivities would be associated with to the dark variants of ordinary particles having essentially same masses as the ordinary particles.

Unless one assumes fractionization, the invariance of $E_F \propto \hbar_{eff}^2 n^{2/3}$ in $\hbar$ increasing transition would require that the density of Cooper pairs in large $\hbar$ phase is scaled down by an appropriate factor. This means that supra current intensities, which are certainly measurable quantities, are also scaled down. Of course, it could happen that E_F is scaled up and this would conform with the scaling of the gap energy.

Quantum critical super-conductors in TGD framework

For quantum critical super-conductivity in heavy fermions systems, a small variation of pressure near quantum criticality can destroy ferromagnetic (anti-ferromagnetic) order so that Curie (Neel) temperature goes to zero. The prevailing spin fluctuation theory [D12] assumes that these transitions are induced by long ranged and slow spin fluctuations at critical pressure P_c. These fluctuations make and break Cooper pairs so that the idea of super-conductivity restricted around critical point is indeed conceivable.

Heavy fermion systems, such as cerium-indium alloy $CeIn_3$ are very sensitive to pressures and a tiny variation of density can drastically modify the low temperature properties of the systems. Also other systems of this kind, such as $CeCu_2Ge_2$, $CeIn_3$, $CePd_2Si_2$ are known [D45, D15]. In these cases super-conductivity appears around anti-ferromagnetic quantum critical point.

The last experimental breakthrough in quantum critical super-conductivity was made in Grenoble [D30]. URhGe alloy becomes super-conducting at $T_c = .280$ K, loses its super-conductivity at $H_c = 2$ Tesla, and becomes again super-conducting at $H_c = 12$ Tesla and loses its super-conductivity again at $H = 13$ Tesla. The interpretation is in terms of a phase transition changing the magnetic order inducing the long range spin fluctuations.

TGD based models of atomic nucleus [K108] and condensed matter [K45] assume that weak gauge bosons with Compton length of order atomic radius play an essential role in the nuclear and condensed matter physics. The assumption that condensed matter nuclei possess anomalous weak charges explains the repulsive core of potential in van der Waals equation and the very low compressibility of condensed matter phase as well as various anomalous properties of water phase, provide a mechanism of cold fusion and sono-fusion, etc. [K45, K43]. The pressure sensitivity of these systems would directly reflect the physics of exotic quarks and electro-weak gauge bosons.

A possible mechanism behind the phase transition to super-conductivity could be the scaling up of the sizes of the space-time sheets of nuclei.

Also the electrons of Cooper pair (and only these) could make a transition to large $\hbar$ phase. This transition would induce quantum overlap having geometric overlap as a space-time correlate. The formation of flux tubes between neighboring atoms would be part of the mechanism. For instance, the criticality condition $4n^2\alpha = 1$ for BE condensate of n Cooper pairs would give $n = 6$ for the size of a higher level quantum unit possibly formed formed from Cooper pairs. If one does not assume invariance of energies obtained by fractionization of principal quantum number, this transition has dramatic effects on the spectrum of atomic binding energies scaling as $1/\hbar^2$ and practically universal spectrum of atomic energies would result [K43] not depending much on nuclear charge. It seems that this prediction is non-physical.

Quantum critical super-conductors resemble superconductors of type I with $\lambda \ll \xi$ for which defects near thermodynamical criticality are complex structures looking locally like stripes of thickness λ. These structures are however dynamical in super-conducting phase. Quite generally, long range quantum fluctuations due to the presence of two competing phases would manifest as complex dynamical structures consisting of stripes and their boundaries. These patterns are dynamical rather than static as in the case of ordinary spin glass phase so that quantum spin glass or 4-D spin glass is a more appropriate term. The breaking of classical non-determinism for vacuum extremals indeed makes possible space-time correlates for quantum non-determinism and this makes TGD Universe a 4-dimensional quantum spin glass.

Could quantum criticality make possible new kinds of high T_c super-conductors?

The transition to large $\hbar = r\hbar_0$ phase increases various length scales by r and makes possible long range correlations even at high temperatures. Hence the question is whether large $\hbar$ phase could correspond to ordinary high T_c super-conductivity. If this were the case in the case of ordinary high T_c super-conductors, the actual value of coherence length ξ would vary in the range $5 - 20$ Angstrom scaled up by a factor r. For effectively D-dimensional super-conductor The density of Cooper pairs would be scaled down by an immensely small factor $1/r^D$ from its value deduced from Fermi energy.

Large $\hbar$ phase for some nuclei might be involved and make possible large space-time sheets of size at least of order of ξ at which conduction electrons forming Cooper pairs would topologically condense like quarks around hadronic space-time sheets (in [K45] a model of water as a partially dark matter with one fourth of hydrogen ions in large $\hbar$ phase is developed).

Consider for a moment the science fictive possibility that super conducting electrons for some quantum critical super-conductors to be discovered or already discovered correspond to large $\hbar$ phase with $\hbar = r\hbar_0$ keeping in mind that this affects only quantum corrections in perturbative approach but not the lowest order classical predictions of quantum theory. For $r \simeq n2^{k11}$ with $(n, k) = (1, 1)$ the size of magnetic body would be $L(149) = 5$ nm, the thickness of the lipid layer of cell membrane. For $(n, k) = (1, 2)$ the size would be $L(171) = 10$ μm, cell size. If the density of Cooper pairs is of same order of magnitude as in case of ordinary super conductors, the critical temperature is scaled up by 2^{k11}. Already for $k = 1$ the critical temperature of 1 K would be scaled up to $4n^2 \times 10^6$ K if n_c is not changed. This assumption is not consistent with the assumption that Fermi energy remains non-relativistic. For $n = 1$ $T_c = 400$ K would be achieved for $n_c \to 10^{-6}n_c$, which looks rather reasonable since Fermi energy transforms as $E_F \to 8 \times 10^3 E_F$ and remains non-relativistic. H_c would scale down as $1/\hbar$ and for $H_c = .1$ Tesla the scaled down critical field would be $H_c = .5 \times 10^{-4}$ Tesla, which corresponds to the nominal value of the Earth's magnetic field.

Quantum critical super-conductors become especially interesting if one accepts the identification of living matter as ordinary matter quantum controlled by macroscopically quantum coherent dark matter. One of the basic hypothesis of TGD inspired theory of living matter is that the magnetic flux tubes of the Earth's magnetic field carry a super-conducting phase and the spin triplet Cooper pairs of electrons in large $\hbar$ phase might realize this dream. That the value of Earth's magnetic field is near to its critical value could have also biological implications.

6.2.4   Space-Time Description Of The Mechanisms OfSuper-Conductivity

The application of ideas about dark matter to nuclear physics and condensed matter suggests that dark color and weak forces should be an essential element of the chemistry and condensed matter physics. The continual discovery of new super-conductors, in particular of quantum critical superconductors, suggests that super-conductivity is not well understood. Hence super-conductivity provides an obvious test for these ideas. In particular, the idea that wormhole contacts regarded as parton pairs living at two space-time sheets simultaneously, provides an attractive universal mechanism for the formation of Cooper pairs and is not so far-fetched as it might sound first.

Leading questions

It is good to begin with a series of leading questions. The first group of questions is inspired by experimental facts about super-conductors combined with TGD context.

1. The work of Rabinowitch [D59] suggests that that the basic parameters of super-conductors might be rather universal and depend on T_c and conduction electron density only and be to a high degree independent of the mechanism of super-conductivity. This is in a sharp contrast to the complexity of even BCS model with its somewhat misty description of the phonon exchange mechanism.
   Questions: Could there exist a simple universal description of various kinds of super-conductivities?

2. The new super-conductors possess relatively complex chemistry and lattice structure.
   Questions: Could it be that complex chemistry and lattice structure makes possible something very simple describable in terms of quantum criticality. Could it be that the transversal oscillations magnetic flux tubes allow to understand the formation of Cooper pairs at T_{c1} and their reconnections generating very long flux tubes the emergence of supra currents at T_c?

3. The effective masses of electrons in ferromagnetic super-conductors are in the range of 10-100 electron masses [D45] and this forces to question the idea that ordinary Cooper pairs are current carriers.
   Questions: Can one consider the possibility that the p-adic length scale of say electron can vary so that the actual mass of electron could be large in condensed matter systems? For quarks and neutrinos this seems to be the case [K64, K77]. Could it be that the Gaussian Mersennes $(1+i)^k - 1$, $k = 151, 157, 163, 167$ spanning the p-adic lengthscale range 10 nm-2.5 μm very relevant from the point of view of biology correspond to p-adic length especially relevant for super-conductivity?

   Second group of questions is inspired by quantum classical correspondence.

1. Quantum classical correspondence in its strongest form requires that bound state formation involves the generation of flux tubes between bound particles. The weaker form of the principle requires that the particles are topologically condensed at same space-time sheet. In the case of Cooper pairs in ordinary superconductors the length of join along boundaries bonds between electrons should be of order $10^3 - 10^4$ Angstroms. This looks rather strange and it seems that the latter option is more sensible.
   Questions: Could quantum classical correspondence help to identify the mechanism giving rise to Cooper pairs?

2. Quantum classical correspondence forces to ask for the space-time correlates for the existing quantum description of phonons.
   Questions: Can one assign space-time sheets with phonons or should one identify them as oscillations of say space-time sheets at which atoms are condensed? Or should the microscopic description of phonons in atomic length scales rely on the oscillations of wormhole contacts connecting atomic space-time sheets to these larger space-time sheets? The identification of phonons as wormhole contacts would be completely analogous to the similar identification of gauge bosons except that phonons would appear at higher levels of the hierarchy of space-time sheets and would be emergent in this sense. As a matter fact, even gauge bosons as

pairs of fermion and anti-fermion are emergent structures in TGD framework and this plays fundamental role in the construction of QFT limit of TGD in which bosonic part of action is generated radiatively so that all coupling constants follow as predictions [**?**]. Could Bose-Einstein condensates of wormhole contacts be relevant for the description of super-conductors or more general macroscopic quantum phases?

The third group of questions is inspired by the new physics predicted or by TGD.

1. TGD predicts a hierarchy of macroscopic quantum phases with large Planck constant.
   Questions: Could large values of Planck constant make possible exotic electronic super-conductivities? Could even nuclei possess large $\hbar$ (super-fluidity)?

2. TGD predicts that classical color force and its quantal counterpart are present in all length scales.
   Questions: Could color force, say color magnetic force which play some role in the formation of Cooper pair. The simplest model of pair is as a space-time sheet with size of order ξ so that the electrons could be "outside" the background space-time. Could the Coulomb interaction energy of electrons with positively charged wormhole throats carrying parton numbers and feeding em gauge flux to the large space-time sheet be responsible for the gap energy? Could wormhole throats carry also quark quantum numbers. In the case of single electron condensed to single space-time sheet the em flux could be indeed fed by a pair of $u\bar{u}$ and $\bar{d}d$ type wormhole contacts to a larger space-time sheet. Could the wormhole contacts have a net color? Could the electron space-time sheets of the Cooper pair be connected by long color flux tubes to give color singlets so that dark color force would be ultimately responsible for the stability of Cooper pair?

3. Suppose that one takes seriously the ideas about the possibility of dark weak interactions with the Compton scale of weak bosons scaled up to say atomic length scale so that weak bosons are effectively massless below this length scale [K45].
   Questions: Could the dark weak length scale which is of order atomic size replace lattice constant in the expression of sound velocity? What is the space-time correlate for sound velocity?

Photon massivation, coherent states of Cooper pairs, and wormhole contacts

The existence of wormhole contacts is one of the most stunning predictions of TGD. First I realized that wormhole contacts can be regarded as parton-antiparton pairs with parton and antiparton assignable to the light-like causal horizons accompanying wormhole contacts. Then came the idea that Higgs particle could be identified as a wormhole contact. It was soon followed by the identification all bosonic states as wormhole contacts [K64]. Finally I understood that this applies also to their super-symmetric partners, which can be also fermion [**?**]. Fermions and their super-partners would in turn correspond to wormhole throats resulting in the topological condensation of small deformations of CP_2 type vacuum extremals with Euclidian signature of metric to the background space-time sheet. This framework opens the doors for more concrete models of also super-conductivity involving the effective massivation of photons as one important aspect in the case of ordinary super-conductors.

There are two types of wormhole contacts. Those of first type correspond to elementary bosons. Wormhole contacts of second kind are generated in the topological condensation of space-time sheets carrying matter and form a hierarchy. Classical radiation fields realized in TGD framework as oscillations of space-time sheets would generate wormhole contacts as the oscillating space-time sheet develops contacts with parallel space-time sheets (recall that the distance between space-time sheets is of order CP_2 size). This realizes the correspondence between fields and quanta geometrically. Phonons could also correspond to wormhole contacts of this kind since they mediate acoustic oscillations between space-time sheets and the description of the phonon mediated interaction between electrons in terms of wormhole contacts might be useful also in the case of super-conductivity. Bose-Einstein condensates of wormhole contacts might be highly relevant for the formation of macroscopic quantum phases. The formation of a coherent state of wormhole contacts would be the counterpart for the vacuum expectation value of Higgs.

The notions of coherent states of Cooper pairs and of charged Higgs challenge the conservation of electromagnetic charge. The following argument however suggests that coherent states of wormhole contacts form only a part of the description of ordinary super-conductivity. The basic observation is that wormhole contacts with vanishing fermion number define space-time correlates for Higgs type particle with fermion and anti-fermion numbers at light-like throats of the contact.

The ideas that a genuine Higgs type photon massivation is involved with super-conductivity and that coherent states of Cooper pairs really make sense are somewhat questionable since the conservation of charge and fermion number is lost for coherent states. A further questionable feature is that a quantum superposition of many-particle states with widely different masses would be in question. These interpretational problems can be resolved elegantly in zero energy ontology [K34] in which the total conserved quantum numbers of quantum state are vanishing. In this picture the energy, fermion number, and total charge of any positive energy state are compensated by opposite quantum numbers of the negative energy state in geometric future. This makes possible to speak about superpositions of Cooper pairs and charged Higgs bosons separately in positive energy sector.

If this picture is taken seriously, super-conductivity can be seen as providing a direct support for both the hierarchy of scaled variants of standard model physics and for the zero energy ontology.

Space-time correlate for quantum critical superconductivity

The explicit model for high T_c super-conductivity relies on quantum criticality involving long ranged quantum fluctuations inducing reconnection of flux tubes of local (color) magnetic fields associated with parallel spins associated with stripes to form long flux tubes serving as wires along which Cooper pairs flow. Essentially [D5] [D5] type phenomenon would be in question. The role of the doping by holes is to make room for Cooper pairs to propagate by the reconnection mechanism: otherwise Fermi statistics would prevent the propagation. Too much doping reduces the number of current carriers, too little doping leaves too little room so that there exists some optimal doping. In the case of high T_c super-conductors quantum criticality corresponds to a quite wide temperature range, which provides support for the quantum criticality of TGD Universe. The probability $p(T)$ for the formation of reconnections is what matters and exceeds the critical value at T_c.

6.2.5 Super-Conductivity At Magnetic Flux Tubes

Super-conductivity at the magnetic flux tubes of magnetic flux quanta is one the basic hypothesis of the TGD based model of living matter. There is also evidence for magnetically mediated super-conductivity in extremely pure samples [D33]. The magnetic coupling was only observed at lattice densities close to the critical density at which long-range magnetic order is suppressed. Quantum criticality that long flux tubes serve as pathways along which Cooper pairs can propagate. In anti-ferromagnetic phase these pathways are short-circuited to closed flux tubes of local magnetic fields.

Almost the same model as in the case of high T_c and quantum critical super-conductivity applies to the magnetic flux tubes. Now the flux quantum contains BE condensate of exotic Cooper pairs interacting with wormhole contacts feeding the gauge flux of Cooper pairs from the magnetic flux quantum to a larger space-time sheet. The interaction of spin 1 Cooper pairs with the magnetic field of flux quantum orients their spins in the same direction. Large value of $\hbar$ guarantees thermal stability even in the case that different space-time sheets are not thermally isolated.

The understanding of gap energy is not obvious. The transversal oscillations of magnetic flux tubes generated by spin flips of electrons define the most plausible candidate for the counterpart of phonons. In this framework phonon like states identified as wormhole contacts would be created by the oscillations of flux tubes and would be a secondary phenomenon.

Large values of $\hbar$ allow to consider not only the Cooper pairs of electrons but also of protons and fermionic ions. Since the critical temperature for the formation of Cooper pairs is inversely proportional to the mass of the charge carrier, the replacement of electron with proton or ion would require a scaling of $\hbar$. If T_{c1} is proportional to $\hbar^2$, this requires scaling by $(m_p/m_e)^{1/2}$. For $T_{c1} \propto \hbar$ scaling by $m_p/m_e \simeq 2^{11}$ is required. This inspired idea that powers of 2^{11} could define favored values of $\hbar/\hbar_0$. This hypothesis is however rather ad hoc and turned out to be too restrictive.

Besides Cooper pairs also Bose-Einstein condensates of bosonic ions are possible in large $\hbar$ phase and would give rise to super-conductivity. TGD inspired nuclear physics predicts the existence of exotic bosonic counterparts of fermionic nuclei with given (A, Z) [L3], [L3].

Superconductors at the flux quanta of the Earth's magnetic field

Magnetic flux tubes and magnetic walls are the most natural candidates for super-conducting structures with spin triplet Cooper pairs. Indeed, experimental evidence relating to the interaction of ELF em radiation with living matter suggests that bio-super-conductors are effectively 1- or 2-dimensional. $D \leq 2$-dimensionality is guaranteed by the presence of the flux tubes or flux walls of, say, the magnetic field of Earth in which charge carries form bound states and the system is equivalent with a harmonic oscillator in transversal degrees of freedom.

The effect of Earth's magnetic field is completely negligible at the atomic space-time sheets and cannot make super conductor 1-dimensional. At cellular sized space-time sheets magnetic field makes possible transversal the confinement of the electron Cooper pairs in harmonic oscillator states but does not explain energy gap which should be at the top of 1-D Fermi surface. The critical temperature extremely low for ordinary value of $\hbar$ and either thermal isolation between space-time sheets or large value of $\hbar$ can save the situation.

An essential element of the picture is that topological quantization of the magnetic flux tubes occurs. In fact, the flux tubes of Earth's magnetic field have thickness of order cell size from the quantization of magnetic flux. The observations about the effects of ELF em fields on bio-matter [J30] suggest that similar mechanism is at work also for ions and in fact give very strong support for bio-super conductivity based on the proposed mechanism.

Energy gaps for superconducting magnetic flux tubes and walls

Besides the formation of Cooper pairs also the Bose-Einstein condensation of charge carriers to the ground state is needed in order to have a supra current. The stability of Bose-Einstein condensate requires an energy gap $E_{g,BE}$ which must be larger than the temperature at the magnetic flux tube.

Several energies must be considered in order to understand $E_{g,BE}$.

1. The Coulombic binding energy of Cooper pairs with the wormhole contacts feeding the em flux from magnetic flux tube to a larger space-time sheet defines an energy gap which is expected to be of order $E_{g,BE} = \alpha/L(k)$ giving $E_g \sim 10^{-3}$ eV for $L(167) = 2.5$ μm giving a rough estimate for the thickness of the magnetic flux tube of the Earth's magnetic field $B = .5 \times 10^{-4}$ Tesla.

2. In longitudinal degrees of freedom of the flux tube Cooper pairs can be described as particles in a one-dimensional box and the gap is characterized by the length L of the magnetic flux tube and the value of $\hbar$. In longitudinal degrees of freedom the difference between $n = 2$ and $n = 1$ states is given by $E_0(k_2) = 3h^2/4m_e L^2(k_2)$. Translational energy gap $E_g = 3E_0(k_2) = 3h^2/4m_e L^2(k_2)$ is smaller than the effective energy gap $E_0(k_1) - E_0(k_2) = h^2/4m_e L^2(k_1) - h^2/4m_e L^2(k_2)$ for $k_1 > k_2 + 2$ and identical with it for $k_1 = k_2 + 2$. For $L(k_2 = 151)$ the zero point kinetic energy is given by $E_0(151) = 20.8$ meV so that $E_{g,BE}$ corresponds roughly to a temperature of 180 K. For magnetic walls the corresponding temperature would be scaled by a factor of two to 360 K and is above room temperature.

3. Second troublesome energy gap relates to the interaction energy with the magnetic field. The magnetic interaction energy E_m of Cooper pair with the magnetic field consists of cyclotron term $E_c = n\hbar eB/m_e$ and spin-interaction term which is present only for spin triplet case and is given by $E_s = \pm\hbar eB/m_e$ depending on the orientation of the net spin with magnetic field. In the magnetic field $B_{end} = 2B_E/5 = .2$ Gauss ($B_E = .5$ Gauss is the nominal value of the Earth's magnetic field) explaining the effects of ELF em fields on vertebrate brain, this energy scale is $\sim 10^{-9}$ eV for $\hbar_0$ and $\sim 1.6 \times 10^{-5}$ eV for $\hbar = 2^{14} \times \hbar_0$.

The smallness of translational and magnetic energy gaps in the case of Cooper pairs at Earth's magnetic field could be seen as a serious obstacle.

1. Thermal isolation between different space-time sheets provides one possible resolution of the problem. The stability of the Bose-Einstein condensation is guaranteed by the thermal isolation of space-time if the temperature at the magnetic flux tube is below E_m. This can be achieved in all length scales if the temperature scales as the zero point kinetic energy in transversal degrees of freedom since it scales in the same manner as magnetic interaction energy.

2. The transition to large $\hbar$ phase could provide a more elegant way out of the difficulty. The criterion for a sequence of transitions to a large $\hbar$ phase could be easily satisfied if there is a large number of charge Cooper pairs at the magnetic flux tube. Kinetic energy gap remains invariant if the length of the flux tube scales as $\hbar$. If the magnetic flux is quantized as a multiple of $\hbar$ and flux tube thickness scales as $\hbar^2$, B must scale as $1/\hbar$ so that also magnetic energy remains invariant under the scaling. This would allow to have stability without assuming low temperature at magnetic flux tubes.

6.3 TGD Based Model For High T_c Super Conductors

High T_c superconductors are quantum critical and involve in an essential magnetic structures, they provide an attractive application of the general vision for the model of super-conductivity based on magnetic flux tubes.

6.3.1 Some Properties Of High T_c Super Conductors

Quite generally, high T_c super-conductors are cuprates with CuO layers carrying the supra current. The highest known critical temperature for high T_c superconductors is 164 K and is achieved under huge pressure of 3.1×10^5 atm for LaBaCuO. High T_c super-conductors are known to be super conductors of type II.

This is however a theoretical deduction following from the assumption that the value of Planck constant is ordinary. For $\hbar = 2^{14}\hbar_0$ (say) ξ would be scaled up accordingly and type I super-conductor would be in question. These super-conductors are characterized by very complex patterns of penetrating magnetic field near criticality since the surface area of the magnetic defects is maximized. For high T_c super-conductors the ferromagnetic phase could be regarded as an analogous to defect and would indeed have very complex structure. Since quantum criticality would be in question the stripe structure would fluctuate with time too in accordance with 4-D spin glass character.

The mechanism of high T_c super conductivity is still poorly understood [D50, D52].

1. It is agreed that electronic Cooper pairs are charge carriers. It is widely accepted that electrons are in relative d-wave state rather than in s-wave (see [D44] and the references mentioned in [D50]). Cooper pairs are believed to be in spin triplet state and electrons combine to form $L = 2$ angular momentum state. The usual phonon exchange mechanism does not generate the attractive interaction between the members of the Cooper pair having spin. There is also a considerable evidence for BCS type Cooper pairs and two kinds of Cooper pairs could be present.

2. High T_c super conductors have spin glass like character [D48]. High T_c superconductors have anomalous properties also above T_c suggesting quantum criticality implying fractal scaling of various observable quantities such as resistivity. At high temperatures cuprates are anti-ferromagnets and Mott insulators meaning freezing of the electrons. Superconductivity and conductivity are believed to occur along dynamical stripes which are antiferromagnetic defects.

3. These findings encourage to consider the interpretation in terms of quantum criticality in which some new form of super conductivity which is not based on quasiparticles is involved. This super-conductivity would be assignable with the quantum fluctuations destroying antiferromagnetic order and replacing it with magnetically disordered phase possibly allowing phonon induced super-conductivity.

4. The doping of the super-conductor with electron holes is essential for high T_c superconductivity, and there is a critical doping fraction $p = .14$ at which T_c is highest. The interpretation is that holes make possible for the Cooper pairs to propagate. There is considerable evidence that holes gather on one-dimensional stripes with thickness of order few atom sizes and lengths in the range 1-10 nm [D52], which are fluctuating in time scale of 10^{-12} seconds. These stripes are also present in non-superconducting state but in this case they do not fluctuate appreciably. The most plausible TGD based interpretation is in terms of fluctuations of magnetic flux tubes allowing for the formation of long connected flux tubes making super-conductivity possible. The fact that the fluctuations would be oscillations analogous to acoustic wave and might explain the BCS type aspects of high T_c super-conductivity.

5. T_c is inversely proportional to the distance L between the stripes. A possible interpretation would be that full super-conductivity requires de-localization of electrons also with respect to stripes so that T_c would be proportional to the hopping probability of electron between neighboring stripes expected to be proportional to $1/L$ [D52].

From free fermion gas to Fermi liquids to quantum critical systems

The article of Jan Zaanen [D51] gives an excellent non-technical discussion of various features of high T_c super-conductors distinguishing them from BCS super-conductors. After having constructed a color flux tube model of Cooper pairs I found it especially amusing to learn that the analogy of high T_c super-conductivity as a quantum critical phenomenon involving formation of dynamical stripes to QCD in the vicinity of the transition to the confined phase leading to the generation of string like hadronic objects was emphasized also by Zaanen.

BCS super-conductor behaves in a good approximation like quantum gas of non-interacting electrons. This approximation works well for long ranged interactions and the reason is Fermi statistics plus the fact that Fermi energy is much larger than Coulomb interaction energy at atomic length scales.

For strongly interacting fermions the description as Fermi liquid (a notion introduced by Landau) has been dominating phenomenological approach. ^{3}He provides a basic example of Fermi liquid and already here a paradox is encountered since low temperature collective physics is that of Fermi gas without interactions with effective masses of atoms about 6 times heavier than those of real atoms whereas short distance physics is that of a classical fluid at high temperatures meaning a highly correlated collective behavior.

It should be noticed that many-sheeted space-time provides a possible explanation of the paradox. Space-time sheets containing join along boundaries blocks of ^3He atoms behave like gas whereas the ^3He atoms inside these blocks form a liquid. An interesting question is whether the ^3He atoms combine to form larger units with same spin as ^3He atom or whether the increase of effective mass by a factor of order six means that $\hbar$ as a unit of spin is increased by this factor forcing the basic units to consist of Bose-Einstein condensate of 3 Cooper pairs.

High T_c super conductors are neither Fermi gases nor Fermi liquids. Cuprate superconductors correspond at high temperatures to doped Mott insulators for which Coulomb interactions dominate meaning that electrons are localized and frozen. Electron spin can however move and the system can be regarded as an anti-ferromagnet. CuO planes are separated by highly oxidic layers and become super-conducting when doped. The charge transfer between the two kinds of layers is what controls the degree of doping. Doping induces somehow a de-localization of charge carriers accompanied by a local melting of anti-ferromagnet.

Collective behavior emerges for high enough doping. Highest T_c results with 15 per cent doping by holes. Current flows along electron stripes. Stripes themselves are dynamical and this is essential for both conductivity and superconductivity. For completely static stripes super-conductivity disappears and quasi-insulating electron crystal results.

Dynamical stripes appear in mesoscopic time and length scales corresponding to 1-10 nm length scale and picosecond time scale. The stripes are in a well-defined sense dual to the magnetized stripe like structures in type I super-conductor near criticality, which suggests analog of type I super-conductivity. The stripes are anti-ferromagnetic defects at which neighboring spins fail to be antiparallel. It has been found that stripes are a very general phenomenon appearing in insulators, metals, and super-conducting compounds [D14].

Quantum criticality is present also above T_c

Also the physics of Mott insulators above T_c reflects quantum criticality. Typically scaling laws hold true for observables. In particular, resistivity increases linearly rather than transforming from T^2 behavior to constant as would be implied by quasi-particles as current carriers. The appearance of so called pseudo-gap [D57] at $T_{c1} > T_c$ conforms with this interpretation. In particular, the pseudo-gap is non-vanishing already at T_{c_1} and stays constant rather than starting from zero as for quasi-particles.

Results from optical measurements and neutron scattering

Optical measurements and neutron scattering have provided especially valuable microscopic information about high T_c superconductors allowing to fix the details of TGD based quantitative model.

Optical measurements of copper oxides in non-super-conducting state have demonstrated that optical conductivity $\sigma(\omega)$ is surprisingly featureless as a function of photon frequency. Below the critical temperature there is however a sharp absorption onset at energy of about 50 meV [D38]. The origin of this special feature has been a longstanding puzzle. It has been proposed that this absorption onset corresponds to a direct generation of an electron-hole pair. Momentum conservation implies that the threshold for this process is $E_g + E$, where E is the energy of the "gluon" which binds electrons of Cooper pair together. In the case of ordinary super-conductivity E would be phonon energy.

Soon after measurements, it was proposed that in absence of lattice excitations photon must generate two electron-hole pairs such that electrons possess opposite momenta [D38]. Hence the energy of the photon would be $2E_g$. Calculations however predicted soft rather than sharp onset of absorption since pairs of electron-hole pairs have continuous energy spectrum. There is something wrong with this picture.

Second peculiar characteristic [D41, D35, D24] of high T_c super conductors is resonant neutron scattering at excitation energy $E_w = 41$ meV of super conductor. This scattering occurs only below the critical temperature, in spin-flip channel and for a favored momentum exchange $(\pi/a, \pi/a)$, where a denotes the size of the lattice cube [D41, D35, D24]. The transferred energy is concentrated in a remarkably narrow range around E_w rather than forming a continuum.

In [D11] is is suggested that e-e resonance with spin one gives rise to this excitation. This resonance is assumed to play the same role as phonon in the ordinary super conductivity and e-e resonance is treated like phonon. It is found that one can understand the dependence of the second derivative of the photon conductivity $\sigma(\omega)$ on frequency and that consistency with neutron scattering data is achieved. The second derivative of $\sigma(\omega)$ peaks near 68 meV and assuming $E = E_g + E_w$ they found nearly perfect match using $E_g = 27$ meV. This would suggest that the energy of the excitations generating the binding between the members of the Cooper pair is indeed 41 meV, that two electron-hole pairs and excitation of the super conductor are generated in photon absorption above threshold, and that the gap energy of the Cooper pair is 27 meV. Of course, the theory of Carbotte *et al* does not force the "gluon" to be triplet excitation of electron pair. Also other possibilities can be considered. What comes in mind are spin flip waves of the spin lattice associated with stripe behaving as spin 1 waves.

In TGD framework more exotic options become possible. The transversal fluctuations of stripes- or rather of the magnetic flux tubes associated with the stripes- could define spin 1 excitations analogous to the excitations of a string like objects. Gauge bosons are identified as wormhole contacts in quantum TGD and massive gauge boson like state containing electron-positron pair or quark-antiquark pair could be considered.

6.3.2 TGD Inspired Vision About High T_c Superconductivity

The following general view about high T_c super-conductivity as quantum critical phenomenon suggests itself. It must be emphasized that this option is one of the many that one can imagine and distinguished only by the fact that it is the minimal option.

The interpretation of critical temperatures

The two critical temperatures T_c and $T_{c_1} > T_c$ are interpreted as critical temperatures. The recent observation that there exists a spectroscopic signature of high T_c super-conductivity, which prevails up to T_{c_1} [D8], supports the interpretation that Cooper pairs exist already below T_{c1} but that for some reason they cannot form a coherent super-conducting state.

One can imagine several alternative TGD based models but for the minimal option is the following one.

1. T_{c_1} would be the temperature for the formation of two-phase system consisting of ordinary electrons and of Cooper pairs with a large value of Planck constant explaining the high critical temperature.

2. Magnetic flux tubes are assumed to be carriers of supra currents. These flux tubes are very short in in anti-ferromagnetic phase. The holes form stripes making them positively charged so that they attract electrons. If the spins of holes tend to form parallel sequences along stripes, they generate dipole magnetic fields in scales of order stripe length at least. The corresponding magnetic flux tubes are assumed to be carriers of electrons and Cooper pairs. The flux tube structures would be closed so that the supra currents associated with these flux tubes would be trapped in closed loops above T_c.

3. Below T_{c1} transversal fluctuations of the flux tubes structures occur and can induce reconnections giving rise to longer flux tubes. Reconnection can occur in two ways. Recall that upwards going outer flux tubes of the dipole field turn downwards and eventually fuse with the dipole core. If the two dipoles have opposite directions the outer flux tube of the first (second) dipole can reconnect with the inward going part of the flux tube of second (first) dipole. If the dipoles have same direction, the outer flux tubes of the dipoles reconnect with each other. Same applies to the inwards going parts of the flux tubes and the dipoles fuse to a single deformed dipole if all flux tubes reconnect. This alternative looks more plausible. The reconnection process is in general only partial since dipole field consists of several flux tubes.

4. The reconnections for the flux tubes of neighboring almost dipole fields occur with some probability $p(T)$ and make possible finite conductivity. At T_c the system the fluctuations of the flux tubes become large and also $p(T, L)$, where L is the distance between stripes, becomes large and the reconnection leads to a formation of long flux tubes of length of order coherence length at least and macroscopic supra currents can flow. One also expects that the reconnection occurs for practically all flux tubes of the dipole field. Essentially a percolation type phenomenon [D5] would be in question. Scaling invariance suggests $p_c(T, L) = p_c(TL/\hbar)$, where L is the distance between stripes, and would predict the observed $T_c \propto \hbar/L$ behavior. Large value of $\hbar$ would explain the high value of T_c.

This model relates in an interesting manner to the vision of Zaanen [D54] expressed in terms of the highway metaphor visualizing stripes as quantum highways along which Cooper pairs can move. In antiferromagnetic phase the traffic is completely jammed. The doping inducing electron holes allows to circumvent traffic jam due to the Fermi statistics generates stripes along which the traffic flows in the sense of ordinary conductivity. In TGD framework highways are replaced with flux tubes and the topology of the network of highways fluctuates due to the possibility of reconnections. At quantum criticality the reconnections create long flux tubes making possible the flow of supra currents.

The interpretation of fluctuating stripes in terms of 1-D phonons

In TGD framework the phase transition to high T_c super-conductivity would have as a correlate fluctuating stripes to which supra currents are assigned. Note that the fluctuations occur also for $T > T_c$ but their amplitude is smaller. Stripes would be parallel to the dark magnetic flux tubes along which dark electron current flows above T_c. The fluctuations of magnetic flux tubes whose amplitude increases as T_c is approached induce transverse oscillations of the atoms of stripes representing 1-D transverse phonons.

The transverse fluctuations of stripes have naturally spin one character in accordance with the experimental facts. They allow identification as the excitations having 41 meV energy and would propagate in the preferred diagonal direction $(\pi/a, \pi/a)$. Dark Cooper pairs would have a gap energy of 27 meV. Neutron scattering resonance could be understood as a generation of these 1-D phonons and photon absorption a creation of this kind of phonon and breaking of dark Cooper pair. The transverse oscillations could give rise to the gap energy of the Cooper pair below T_{c1} and for the formation of long flux tubes below T_c but one can consider also other mechanisms based on the new physics predicted by TGD.

Various lattice effects such as superconductivity-induced phonon shifts and broadenings, possible isotope effects in T_c (questionable), the penetration depth, infrared and photoemission spectra have been observed in the cuprates [D3]. A possible interpretation is that ordinary phonons are replaced by 1-D phonons defined by the transversal excitations of stripes but do not give rise to the binding of the electrons of the Cooper pair but to reconnection of flux tubes. An alternative proposal which seems to gain experimental support is that spin waves appearing near antiferromagnetic phase transitions replace phonons.

More precise view about high T_c superconductivity taking into account recent experimental results

There are more recent results allowing to formulate more precisely the idea about transition to high T_c super-conductivity as a percolation type phenomenon. Let us first summarize the recent picture about high T_c superconductors.

1. 2-dimensional phenomenon is in question. Supra current flows along preferred lattice planes and type II super-conductivity in question. Proper sizes of Cooper pairs (coherence lengths) are $\xi =$1-3 nm. Magnetic length λ is longer than $\xi/\sqrt{2}$.

2. Mechanism for the formation of Cooper pairs is the same water bed effect as in the case of ordinary superconductivity. Phonons are only replaced with spin-density waves for electrons with periodicity in general not that of the underlying lattice. Spin density waves relate closely to the underlying antiferromagnetic order. Spin density waves appear near phase transition to antiferromagnetism.

3. The relative orbital angular mentum of Cooper pair is L=2 ($x^2 - y^2$ wave), and vanishes at origin unlike for ordinary s wave SCs. The spin of the Cooper pair vanishes.

   Consider now the translation of this picture to TGD language. Basic notions are following.

1. Magnetic flux tubes and possibly also dark electrons forming Cooper pairs.

2. The appearence of spin waves means sequences of electrons with opposite spins. The magnetic field associated with them can form closed flux tube containing both spins. Assume that spins-are orthogonal to the lattice plane in which supracurrent flows. Assume that the flux tube branches associated with electron with given spin branches so that it is shared with both neighboring electrons.

3. Electrons of opposite spins at the two portions of the closed flux tube have magnetic interaction energy. The total energy is minimal when the spins are in opposite directions. Thus the closed flux tube tends to favor formation of Cooper pairs.

4. Since magnetic interaction energy is proportional to $h_{eff} = n \times h$, it is expected stabilize the Cooper pairs at high temperatures. For ordinary super-conducti- vity magnetic fields tends to de-stabilize the pairs by trying to force the spins of spin singlet pair to the same direction.

5. This does not yet give super-conductivity. The closed flux tubes associated with paired spins can however reconnect so that longer flux closed flux tubes are formed. If this occurs for entire sequences, one obtains two flux tubes containing electrons with opposite spins forming Cooper pairs: this would be the "highway" and percolation would corresponds to this process. The pairs would form supracurrents in longer scales.

6. The phase phase transitions generating the reconnections could be percolation type phase transition.

This picture might apply also in TGD based model of bio-superconductivity.

1. The stability of dark Cooper pairs assume to reside at magnetic flux tubes is a problem also now. Fermi statistics favors opposite spins but this means that magnetic field tends to spit the pairs if the members of the pair are at the same flux tube.

2. If the members of the pair are at different flux tubes, the situation changes. One can have $L = 1$ and $S = 1$ with parallel spins (ferromagnetism like situation) or $L = 2$ and $S = 0$ state (anti-ferromagnetism like situation). $L > 0$ is necessary since electrons must reside at separate flux tubes.

Nematics and high T_c superconductors

Waterloo physicists discover new properties of superconductivity is the title of article (see `http://tinyurl.com/jfz3l45`) popularizing the work of David Hawthorn, Canada Research Chair Michel Gingras, doctoral student Andrew Achkar and post-doctoral student Zhihao Hao published in Science [D26] (see `http://tinyurl.com/zycahrx`). There is a dose of hype involved. As a matter of fact, it has been known for years that electrons flow along stripes, kind of highways in high T_c superconductors.

This effect is known as nematicity and means that electron orbitals break lattice symmetries and align themselves like a series of rods. Nematicity in long length scales occurs a temperatures below the critical point for super-conductivity. In the above mentioned work cuprate CuO_2 is studied. For non-optimal doping the critical temperature for transition to macroscopic superconductivity is below the maximal critical temperature. Long length scale nematicity is observed in these phases.

In the article by Rosenthal *et al* [D40] (see `http://tinyurl.com/h34347f`) it is however reported that nematicity is in fact preserved above critical temperature as a local order -at least up to the upper critical temperature, which is not easy to understand in the BCS theory of superconductivity. One can say that the stripes are short and short-lived so that genuine super-conductivity cannot take place.

These two observations lend further support for the TGD inspired model of high T_c super-conductivity and bio-superconductivity. It is known that antiferromagnetism is essential for the phase transition to superconductivity but Maxwellian view about electromagnetism and standard quantum theory do not make it easy to understand how. Magnetic flux tube is the first basic new notion provided by TGD. Flux tubes carry dark electrons with scaled up Planck constant $h_{eff} = n \times h$: this is second new notion. This implies scaling up of quantal length scales and in this manner makes also super-conductivity possible.

Magnetic flux tubes in antiferromagnetic materials form short loops. At the upper critical point they however reconnect with some probability to form loops with look locally like parallel flux tubes carrying magnetic fields in opposite directions. The probability of reverse phase transition is so large than there is a competion. The members of Cooper pairs are at parallel flux tubes and have opposite spins so that the net spin of pair vanishes: $S = 0$. At the first critical temperature the average length and lifetime of flux tube highways are too short for macroscopic super-conductivity. At lower critical temperature all flux tubes re-connect permanently average length of pathways becomes long enough.

This phase transition is mathematically analogous to percolation in which water seeping through sand layer wets it completely. The competion between the phases between these two temperatures corresponds to quantum criticality in which phase transitions $h_{eff}/h = n_1 \leftrightarrow n_2$ take place in both directions ($n_1 = 1$ is the most plausible first guess). Earlier I did not fully realize that Zero Energy Ontology provides an elegant description for the situation [L41] [K37, K38, K39, K40]. The reason was that I thought that quantum criticality occurs at single critical temperature rather than temperature interval. Nematicity is indeed detected locally below upper critical temperature and in long length scales below lower critical temperature.

Explanation for the spectral signatures of high T_c superconductor

The model should explain various spectral signatures of high T_c super-conductors. It seems that this is possible at qualitative level at least.

1. Below the critical temperature there is a sharp absorption onset at energy of about $E_a = 50$ meV.

2. Second characteristic [D41, D35, D24] of high T_c super conductors is resonant neutron scattering at excitation energy $E_w = 41$ meV of super conductor also visible only below the critical temperature.

3. The second derivative of $\sigma(\omega)$ peaks near 68 meV and assuming $E = E_g + E_w$ they found nearly perfect match using $E_g = 27$ meV for the energy gap.

   $E_g = 27$ meV has a natural interpretation as energy gap of spin 1 Cooper pair. $E_w = 41$ meV can be assigned to the transversal oscillations of magnetic flux tubes inducing 1-D transversal photons which possibly give rise to the energy gap. $E_a = 50$ meV can be understood if also $S = 0$ Cooper pair for which electrons of the pair reside dominantly at the "outer" dipole flux tube and inner dipole core. The presence of this pair might explain the BCS type aspects of high T_c super-conductivity. This identification would predict the gap energy of $S = 0$ Cooper pair to be $E_g(S = 0) = 9$ meV. Since the critical absorption onset is observed only below T_c these Cooper pairs would become thermally stable at T_c and the formation of long flux tubes should somehow stabilize them. For very long flux tubes the distance of a point of "outer" flux tube from the nearby point "inner" flux tube becomes very long along dipole flux tube. Hence the transformation of $S = 0$ pairs to $S = 1$ pairs is not possible anymore and $S = 0$ pairs are stabilized.

Model for Cooper pairs

The TGD inspired model for Cooper pairs of high T_c super-conductor involves several new physics aspects: large $\hbar$ phases, the notion of magnetic flux tubes. One can also consider the possibility that color force predicted by TGD to be present in all length scales is present.

1. One can consider two options for the topological quantization of the dipole field. It could decompose to a flux tube pattern with a discrete rotational symmetry Z_n around dipole axis or to flux sheets identified as walls of finite thickness invariant under rotations around dipole axis. Besides this there is also inner the flux tube corresponding to the dipole core. For the flux sheet option one can speak about eigenstates of L_z. For flux tube option the representations of Z_n define the counterparts of the angular momentum eigenstates with a cutoff in L_z analogous to a momentum cutoff in lattice. The discretized counterparts of spherical harmonics make sense. The counterparts of the relative angular momentum eigenstates for Cooper pair must be defined in terms of tensor products of these rather than using spherical harmonics assignable with the relative coordinate $r_1 - r_2$. The reconnection mechanism makes sense only for the flux tube option so that it is the only possibility in the recent context.

2. Exotic Cooper pair is modeled as a pair of large $\hbar$ electrons with zoomed up size at space-time representing the dipole field pattern associated with a sequence of holes with same spin. If the members of the pair are at diametrically opposite flux tubes or at the "inner" flux tube (dipole core) magnetic fluxes flow in same direction for electrons and spin 1 Cooper pair is favored. If they reside at the "inner" flux tube and outer flux tube, spin zero state is favored. This raises the question whether also $S = 0$ variant of the Cooper pair could be present.

3. Large $\hbar$ is needed to explain high critical temperature. By the general argument the transition to large $\hbar$ phase occurs in order to reduce the value of the gauge coupling strength - now fine structure constant- and thus guarantee the convergence of the perturbation theory. The generation or positive net charge along stripes indeed means strong electromagnetic interactions at stripe.

Color force in condensed matter length scales is a new physics aspect which cannot be excluded in the case that transverse oscillations of flux tubes do not bind the electrons to form a Cooper pair. Classically color forces accompany any non-vacuum extremal of Kähler action since a non-vanishing induced Kähler field is accompanied by a classical color gauge field with Abelian holonomy. Induced Kähler field is always non-vanishing when the dimension of the CP_2 projection of the space-time surface is higher than 2. One can imagine too alternative scenarios.

1. Electromagnetic flux tubes for which induced Kähler field is non-vanishing carry also classical color fields. Cooper pairs could be color singlet bound states of color octet excitations of electrons (more generally leptons) predicted by TGD and explaining quite impressive number of anomalies [K117]. These states are necessarily dark since the decay widths of gauge bosons do not allow new light fermions coupling to them. The size of these states is of order electron size scale $L(127)$ for the standard value of Planck constant. For the non-standard value of Planck constant it would be scaled up correspondingly. For $r = \hbar/\hbar_0 = 2^{14}$ the size would be around 3.3 Angströms and for $r = 2^{24}$ of order 10 nm. Color binding could be responsible for the formation of the energy gap in this case and would distinguish between ordinary two-electron states and Cooper pair. The state with minimum color magnetic energy corresponds to spin triplet state for two color octed fermions whereas for colored fermion and anti-fermion it corresponds to spin singlet (pion like state in hadron physics).

2. A more complex variant of this picture served as the original model for Cooper pairs. Electrons at given space-time sheet feed their gauge flux to large space-time sheet via wormhole contacts. If the wormhole throats carry quantum numbers of quark and antiquark one can say that in the simplest situation the electron space-time sheet is color singlet state formed by quark and antiquark associated with the upper throats of the wormhole contacts carrying quantum numbers of u quark and $\bar{d}$ quark. It can also happen that the electronic space-time sheets are not color singlet but color octet in which case the situation is analogous to that above. Color force would bind the two electronic space-time sheets to form a Cooper pair. The neighboring electrons in stripe possess parallel spins and could form a pair transforming to a large $\hbar$ Cooper pair bound by color force. The Coulombic binding energy of the charged particles with the quarks and antiquarks assignable to the two wormhole throats feeding the em gauge flux to Y^4 and color interaction would be responsible for the energy gap.

Estimate for the gap energy

If transverse oscillations are responsible for the binding of the Cooper pairs, one expects similar expression for the gap energy as in the case of BCS type super conductors. The 3-D formula for the gap energy reads as

$$
\begin{aligned}
E_g &= \hbar \omega_D exp(-1/X) \ , \\
\omega_D &= (6\pi^2)^{1/3} c_s n^{1/3} \\
X &= n(E_F)U_0 = \frac{3}{2}N(E_F)\frac{U_0}{E_F} \ , \\
n(E_F) &= \frac{3}{2}\frac{N(E_F)}{E_F} \ .
\end{aligned}
$$

(6.3.1)

X depends on the details of the binding mechanism for Cooper pairs and U_0 parameterizes these details.

Since only stripes contribute to high T_c super-conductivity it is natural to replace 3-dimensional formula for Debye frequency in 1-dimensional case with

$$
\begin{aligned}
E_g &= \hbar\omega exp(-1/X) \ , \\
\omega &= kc_s n \ .
\end{aligned}
$$

(6.3.2)

where n is the 1-dimensional density of Cooper pairs and k a numerical constant. X would now correspond to the binding dynamics at the surface of 1-D counterpart of Fermi sphere associated with the stripe.

There is objection against this formula. The large number of holes for stripes suggests that the counterpart of Fermi sphere need not make sense, and one can wonder whether it could be more advantageous to talk about the counterpart of Fermi sphere for holes and treat Cooper pair as a pair of vacancies for this "Fermi sphere". High T_c super conductivity would be 1-D conventional super-conductivity for bound states of vacancies. This would require the replacement of n with the linear density of holes along stripes, which is essentially that of nuclei.

From the known data one can make a rough estimate for the parameter X. If $E_w = hf = 41$ meV is assigned with transverse oscillations the standard value of Planck constant would give $f = f_0 = 9.8 \times 10^{12}$ Hz. In the general case one has $f = f_0/r$. If one takes the 10^{-12} second length scale of the transversal fluctuations at a face value one obtains $r = 10$ as a first guess. $E_g = 27$ meV gives the estimate

$$exp(-1/X) \quad = \quad \frac{E_g}{E_w} \tag{6.3.3}$$

giving $X = 2.39$.

The interpretation in terms of transversal oscillations suggests the dispersion relation

$$f = \frac{c_s}{L} \quad .$$

L is the length of the approximately straight portion of the flux tube. The length of the "outer" flux tube of the dipole field is expected be longer than that of stripe. For $L = x$ nm and $f_D \sim 10^{12}$ Hz one would obtain $c_s = 10^3 x$ m/s.

Estimate for the critical temperatures and for $\hbar$

One can obtain a rough estimate for the critical temperature T_{c1} by following simple argument.

1. The formula for the critical temperature proposed in the previous section generalize in 1-dimensional case to the following formula

$$T_{c1} \quad \leq \quad \frac{h^2}{8m_e}(\frac{n_c}{g})^2 \quad . \tag{6.3.4}$$

   g is the number of spin degrees of freedom for Cooper pair and n_c the 1-D density of Cooper pairs. The effective one-dimensionality allows only single $L = 2$ state localized along the stripe. The $g = 3$ holds true for $S = 1$.

2. By parameterizing n_c as $n_c = (1 - p_h)/a$, $a = x$ Angstrom, and substituting the values of various parameters, one obtains

$$T_{c1} \quad \simeq \quad \frac{r^2(1 - p_h)^2}{9x^2} \times 6.3 \ meV \quad . \tag{6.3.5}$$

3. An estimate for p_h follows from the doping fraction p_d and the fraction p_s of parallel atomic rows giving rise to stripes one can deduce the fraction of holes for a given stripe as

$$p_h \quad = \quad \frac{p_d}{p_s} \quad . \tag{6.3.6}$$

One must of course have $p_d \leq p_s$. For instance, for $p_s = 1/5$ and $p_d = 15$ per cent one obtains $p_h = 75$ per cent so that a length of four atomic units along row contains one Cooper pair on the average. For $T_{c1} = 23$ meV (230 K) this would give the rough estimate $r = 23.3$: $r = 24$ satisfies the Fermat polygon constraint. Contrary to the first guess inspired by the model of bio-superconductivity the value of $\hbar$ would not be very much higher than its standard value. Notice however that the proportionality $T_c \propto r^2$ makes it difficult to explain T_{c1} using the standard value of $\hbar$.

4. One $p_h \propto 1/L$ whereas scale invariance for reconnection probability ($p = p(x = TL/\hbar)$) predicts $T_c = x_c\hbar/L = x_c p_s\hbar/a$. This implies

$$\frac{T_c}{T_{c1}} \;=\; 32\pi^2 \frac{m_e a}{\hbar_0} x^2 g^2 \frac{p_s}{(1 - (p_d/p_s)^2)^2} \frac{x_c}{r} \;. \tag{6.3.7}$$

This prediction allows to test the proposed admittedly somewhat ad hoc formula. For $p_d << p_s$ T_c/T_{c1} does behaves as $1/L$. One can deduce the value of x_c from the empirical data.

5. Note that if the reconnection probability p is a universal function of x as quantum criticality suggests and thus also x_c is universal, a rather modest increase of $\hbar$ could allow to raise T_c to room temperature range.

The value of $\hbar$ is predicted to be inversely proportional to the density of the Cooper pairs at the flux tube. The large value of $\hbar$ needed in the modelling of living system as magnetic flux tube super-conductor could be interpreted in terms of phase transitions which scale up both the length of flux tubes and the distance between the Cooper pairs so that the ratio rn_c remains unchanged.

Coherence lengths

The coherence length for high T_c super conductors is reported to be 5-20 Angstroms. The naïve interpretation would be as the size of Cooper pair. There is however a loophole involved. The estimate for coherence length in terms of gap energy is given by $\xi = \frac{4\hbar v_F}{E_g}$. If the coherence length is estimated from the gap energy, as it seems to be the case, then the scaling up of the Planck constant would increase coherence length by a factor $r = \hbar/\hbar_0$. $r = 24$ would give coherence lengths in the range $12 - 48$ nm.

The interpretation of the coherence length would be in terms of the length of the connected flux tube structure associated with the row of holes with the same spin direction which can be considerably longer than the row itself. As a matter fact r would characterize the ratio of size scales of the "magnetic body" of the row and of row itself. The coherence lengths could relate to the p-adic length scales $L(k)$ in the range $k = 151, 152, .., 155$ varying in the range $(10, 40])$ nm. $k = 151$ correspond to thickness cell membrane.

Why copper and what about other elements?

The properties of copper are somehow crucial for high T_c superconductivity since cuprates are the only known high T_c superconductors. Copper corresponds to $3d^{10}4s$ ground state configuration with one valence electron. This encourages the question whether the doping by holes needed to achieve superconductivity induces the phase transition transforming the electrons to dark Cooper pairs.

More generally, elements having one electron in s state plus full electronic shells are good candidates for doped high T_c superconductors. If the atom in question is also a boson the formation of atomic Bose-Einstein condensates at Cooper pair space-time sheets is favored. Superfluid would be in question. Thus elements with odd value of A and Z possessing full shells plus single s wave valence electron are of special interest. The six stable elements satisfying these conditions are ^{5}Li, ^{39}K, ^{63}Cu, ^{85}Rb, ^{133}Cs, and ^{197}Au.

A new phase of matter in the temperature range between pseudo gap temperature and T_c?

Kram sent a link to a Science Daily popular article titled "High-Temperature Superconductor Spills Secret: A New Phase of Matter?" (see `http://tinyurl.com/49vnvsu`: see also `http://tinyurl.com/yb7rs3fs`). For more details see the article in Science [D27].

Zhi-Xun Shen of the Stanford Institute for Materials and Energy Science (SIMES), a joint institute of the Department of Energy's SLAC National Accelerator Laboratory and Stanford University, led the team of researchers, which discovered that in the temperature region between the pseudo gap temperature and genuine temperature for the transition to super-conducting phase there exists a new phase of matter. The new phase would not be super-conducting but would be characterized by an order of its own which remains to be understood. This phase would be present also in the super-conducting phase.

The announcement does not come as a complete surprise for me. A new phase of matter is what TGD inspired model of high T_c superconductivity indeed predicts. This phase would consist of Cooper pairs of electrons with a large value of Planck constant but associated with magnetic flux tubes with short length so that no macroscopic supra currents would be possible.

The transition to super-conducting phase involves long range fluctuations at quantum criticality and the analog of a phenomenon known as percolation (see `http://tinyurl.com/oytvosv`) [D5]. For instance, the phenomenon occurs for the filtering of fluids through porous materials. At critical threshold the entire filter suddenly wets as fluid gets through the filter. Now this phenomenon would occur for magnetic flux tubes carrying the Cooper pairs. At criticality the short magnetic flux tubes fuse by reconnection to form long ones so that supra currents in macroscopic scales become possible.

It is not clear whether this prediction is consistent with the finding of Shen and others. The simultaneous presence of short and long flux tubes in macroscopically super-conducting phase is certainly consistent with TGD prediction. The situation depends on what one means with super-conductivity. Is super-conductivity super-conductivity in macroscopic scales only or should one call also short scale super-conductivity not giving rise to macroscopic super currents as super-conductivity. In other words: do the findings of Shen's team prove that the electrons above gap temperature do not form Cooper pairs or only that there are no macroscopic supra currents?

Whether the model works as such or not is not a life and death question for the TGD based model. One can quite well imagine that the first phase transition increasing $\hbar$ does not yet produce electron Compton lengths long enough to guarantee that the overlap criterion for the formation of Cooper pairs is satisfied. The second phase transition increasing $\hbar$ would do this and also scale up the lengths of magnetic flux tubes making possible the flow of supra currents as such even without reconnections. Also reconnections making possible the formation of very long flux tubes could be involved and would be made possible by the increase in the length of flux tubes.

6.3.3 Speculations

21-Micrometer mystery

21 micrometer radiation from certain red giant stars have perplexed astronomers for more than a decade [D9]. Emission forms a wide band (with width about 4 micrometers) in the infrared spectrum, which suggests that it comes form a large complex molecule or a solid or simple molecules found around starts. Small molecules are ruled out since they produce narrow emission lines. The feature can be only observed in very precise evolutionary state, in the transition between red giant phase and planetary nebular state, in which star blows off dust that is rich in carbon compounds. There is no generally accepted explanation for 21-micrometer radiation.

One can consider several explanations based on p-adic length scale hypothesis and some explanations might relate to the wormhole based super-conductivity.

1. 21 micrometers corresponds to the photon energy of 59 meV which is quite near to the zero point point kinetic energy 61.5 meV of proton Cooper pair at $k = 139$ space-time sheet estimated from the formula

$$\Delta E(2m_p, 139) = \frac{1}{2} \frac{\pi^2}{(2m_p)L_e(139)^2} = \frac{1}{8}\Delta E(m_p, 137) \simeq 61.5 \ meV \ \ .$$

Here the binding energy of the Cooper pair tending to reduce this estimate is neglected, and this estimate makes sense only apart from a numerical factor of order unity. This energy is liberated when a Cooper pair of protons at $k = 139$ space-time sheet drops to the magnetic flux tube of Earth's magnetic field (or some other sufficiently large space-time sheet). This energy is rather near to the threshold value about 55 meV of the membrane potential.

2. 21 micrometer radiation could also result when electrons at $k = 151$ space-time sheet drop to a large enough space-time sheet and liberate their zero point kinetic energy. Scaling argument gives for the zero point kinetic energy of electron at $k = 151$ space-time sheet the value $\Delta(e, 151) \simeq 57.5$ meV which is also quite near to the observed value. If electron is bound to wormhole with quantum numbers of $\bar{d}$ Coulombic binding energy changes the situation.

3. A possible explanation is as a radiation associated with the transition to high T_c super conducting phase. There are two sources of photons. Radiation could perhaps result from the de-excitations of wormhole BE condensate by photon emission. $\lambda = 20.5$ micrometers is precisely what one expects if the space-time sheet corresponds to $p \simeq 2^k$, $k = 173$ and assumes that excitation energies are given as multiples of $E_w(k) = 2\pi/L_e(k)$. This predicts excitation energy $E_w(173) \simeq 61.5$ meV. Unfortunately, this radiation should correspond to a sharp emission line and cannot explain the wide spectrum.

Are living systems high T_c superconductors?

The idea about cells and axons as superconductors has been one of the main driving forces in development of the vision about many-sheeted space-time. Despite this the realization that the supra currents in high T_c superconductors flow along structure similar to axon and having same crucial length scales came as a surprise. Axonal radius which is typically of order $r = .5$ μm. $r = 151 - 127 = 24$ favored by Mersenne hypothesis would predict $r = .4$ μm. The fact that water is liquid could explain why the radius differs from that predicted in case of high T_c superconductors.

Interestingly, Cu is one of the biologically most important trace elements [D2]. For instance, copper is found in a variety of enzymes, including the copper centers of cytochrome c-oxidase, the Cu-Zn containing enzyme superoxide dismutase, and copper is the central metal in the oxygen carrying pigment hemocyanin. The blood of the horseshoe crab, Limulus polyphemus uses copper rather than iron for oxygen transport. Hence there are excellent reasons to ask whether living matter might be able to build high T_c superconductors based on copper oxide.

Neuronal axon as a geometric model for current carrying "rivers"

Neuronal axons, which are bounded by cell membranes of thickness $L_e(151)$ consisting of two lipid layers of thickness $L_e(149)$ are good candidates for high T_c superconductors in living matter.

These flux tubes with radius .4 μm would define "rivers" along which conduction electrons and various kinds of Cooper pairs flow. Scaled up electrons have size $L_e(k_{eff} = 151)$ corresponding to 10 nm, the thickness of the lipid layer of cell membrane. Also the quantum fluctuating stripes of length 1-10 nm observed in high T_c super conductors might relate to the scaled up electrons with Compton length 10 nm, perhaps actually representing zoomed up electrons!

The original assumption that exotic *resp.* BCS type Cooper pairs reside at boundaries *resp.* interior of the super-conducting rivulet. It would however seem that the most natural option is that the hollow cylindrical shells carry all supra currents and there are no Cooper pairs in the interior. If exotic Cooper pairs reside only at the boundary of the rivulet or the Cooper pairs at boundary remain critical against exotic-BCS transition also below T_c, the time dependent fluctuations of the shapes of stripes accompanying high T_c super-conductivity can be understood as being induced by the fluctuations of membrane like structures. Quantum criticality at some part of the boundary is necessary in order to transform ordinary electron currents to super currents at the ends of rivulets. In biology this quantum criticality would correspond to that of cell membrane.

6.4 Models For Ionic Superconductivity

In this section the model for ionic superconductivity is constructed as a straightforward generalization of the model of high T_c electronic superconductivity. There is however a loophole involved. TGD based model of atomic nucleus predicts that fermionic ions can have bosonic chemical equivalents for which one of the color bonds connecting nucleons to nuclear string is charged. Dark fermionic ions like Na^+, K^+, and Cl^- could be actually exotic ions of this kind having different mass number and be able to form Bose-Einstein condensates. This is required by the recent model for nerve pulse [K92]. The prediction can be tested.

The new model for the topological condensation at magnetic flux quanta of endogenous magnetic field differs radically from the earlier model and allows to understand that effects of ELF em fields on brain. Bose-Einstein condensates of bosonic ions are predicted to be of special importance for the functioning of living systems. Also a quantitative understanding of the effects of Schumann resonances and EEG emerges.

6.4.1 Model For Ionic Superconductivity

Exactly the same mechanisms are expected to work also in the case of ions and the only differences come from the different mass and charge of ion.

1. Magnetic flux tubes are carriers of supra currents and magnetic fields favor the formation of spin 1 Cooper pairs which are parallel and have also spins parallel to the flux tubes. In living matter the flux tubes could be dark magnetic flux tubes connecting different biomolecules. For instance, DNA as topological quantum computer model [K5] assumes that flux tubes connect nucleotides of DNA with the lipid layers of nuclear or cell membrane.

2. Mersenne hypothesis discussed in the introduction is assumed and makes possible precise quantitative predictions using scaling arguments. With the motivation coming from the model of cell membrane as Josephson junction it is also assumed that magnetic field scales as $1/\hbar$ and that the supra currents at the boundaries of flux tubes guarantee that the quantization condition $\oint (p - eA) \cdot dl = 0$ is satisfied. This allows the flux tubes to have a fixed transversal size (cell membrane thickness) irrespective of the value of Planck constant. An attractive hypothesis is that the $B_{end} = 0.2$ Gauss and its $1/\hbar$ scaled variants define preferred values of magnetic field.

3. In the case of ionic super-conductivity there is no antiferromagnetic lattice present. Therefore there is no obvious reason for having higher critical temperature $T_{c,1}$. Percolation type mechanism is possible if a recombination of shorter magnetic flux tubes to form longer ones takes place at critical temperature. According to the model of DNA as topological quantum computer recombination of the flux tubes is a basic mechanism of information processing mechanism in living matter so that percolation type criticality might be present.

4. For large values of $\hbar$ the gap for magnetic cyclotron energies implies that proton Cooper pairs condense to the ground state in the degrees of freedom transversal to the flux tube in which harmonic oscillator states provide a good approximate model. In the longitudinal degrees of freedom one has effectively particle in box. The corresponding energy gap $E = \pi^2 \hbar^2 / 2 m_p L^2$ is below thermal energy at room temperature for flux tube lengths L of order $L(139)$ for ordinary value of $\hbar$. For electron this length scale is by a factor $m_p/m_e \simeq 2^{11}$ longer and corresponds to about 100 nm. The value of flux tube length however scales as $\hbar$ if one assumes that energy does not change in the scaling of $\hbar$. Hence arbitrarily long flux tube lengths are possible. For ion with mass number A the minimum value of $\hbar$ allowing given flux tube length L scales as $\hbar \propto AL$.

5. In the case of bosonic ions there is no need for Cooper pairs and super-conductivity would be due to the Bose-Einstein condensation of ions. TGD based nuclear physics also predicts exotic ions, which are chemically like their fermionic counterparts but are actually bosons. This is made possible by the possibility of the color flux tubes connecting nucleons to nuclear string to carry charges $1, 0, -1$.

$$
\begin{array}{llll}
Ion & f_c/Hz & Pseudo-ion & f_c/Hz \\
{}^{23}Na^+ & 13.1 & {}^{19}Ne_+ & 15.7 \\
{}^{23}Na^+ & 13.1 & {}^{24}Mg_-^{++} & 12.5 \\
{}^{39}K^+ & 7.7 & {}^{40}A_+ & 7.5 \\
{}^{39}K^+ & 7.7 & {}^{40}Ca_-^{++} & 7.5 \\
{}^{35}Cl^- & 8.6 & {}^{40}A_- & 7.5
\end{array}
\tag{6.4.1}
$$

Table 6.1: The modification of cyclotron frequencies of most important ions are modified by simplest replacements with exotic ions

6. Whether the Cooper pairs of fermionic ions can be thermally stable is far from obvious. The model for electronic super-conductivity would suggest transversal fluctuations of the flux tube as the mediator of the attractive interaction winning Coulomb repulsion and making possible the formation of the Cooper pairs.

   One might hope that the ions are trapped to the neighboring nodes of the transversal standing wave type oscillations and in this manner form correlated pairs. The size of the Cooper pairs would correspond to a multiple of wavelength for the transversal oscillations in this case. The approximation of the magnetic flux tube as string would suggest that waves are of form $sin(\omega t)sin(kz)$, $k = \omega$. The frequencies $\omega = n\pi/L$ would be allowed for a flux tube of length L.

   Perhaps it would be more appropriate to say that one has Bose-Einstein condensate of transverse phonons making possible the Bose-Einstein condensate of Cooper pairs. It is quite possible that metabolic energy must be pumped to the Bose-Einstein condensate of transverse oscillations in order to not lose the ionic super-conductivity.

6.4.2 Super conductors of exotic bosonic counterparts of fermionic ions

If ion is boson, no Cooper pairs is needed in order to have a super conductor, and Ca^{++} and Mg^{++} ions at dark magnetic flux tubes with large value of Planck constant could give rise to high T_c super-conductors in this manner. Fermionic ions (Na$^+$, K$^+$, Cl$^-$, ..) would not define supra currents. The explanation of the effects of ELF em fields on vertebrate brain however suggests cyclotron Bose-Einstein condensates of also ions behaving chemically like fermionic ions. Also the model of nerve pulse requires Josephson currents of ions which are chemical equivalents of fermionic ions.

TGD based nuclear physics [L3] allows this kind of ions. The model indeed predicts the possibility of exotic nuclei for which one or more color bonds connecting nucleons to the nuclear string are charged. These exotic nuclei with electronic states identical to those of genuine ions could save the situation. The **Table 6.1** describes how cyclotron frequencies for $B = .2$ Gauss of the most important ions are modified in the simplest replacements with exotic ions. For instance, the notation Mg_-^{++} tells that there is double electronic ionization and electron shell of Argon as usual but that one color bond is negatively charged.

$f_c(K+)$ and $f_c(Cl^-)$ are replaced with the frequency 7.5 Hz and one can do only using the cyclotron frequencies $f(Ca^{++})/2 = 7.5$ Hz, $f_c(Mg^{++}) = 12.5$ Hz, and $f(Ca^{++}) = 15$ Hz. The nominal values of the lowest Schumann frequencies are 7.8 Hz and 14.3 Hz. All ions with relevance for nerve pulse and EEG could be bosonic ions or bosonic pseudo-ions. I do not know how well the needed ionization mechanisms are understood in the standard framework.

6.4.3 More Quantitative Picture About Bose-Einstein Condensates

Cyclotron frequencies of biologically important ions in the endogenous magnetic field $B_{end} = 0.2$ Gauss are involved with the effects of ELF em fields on vertebrate brain and are also central in the model of EEG [K44]. This motivates a more detailed study of these frequencies. Also the cyclotron frequencies of biologically important molecules are interesting.

Ion	f_1/Hz	E_1/eV
$^6Li^+$	50.1	3.3
$^{24}Mg^{2+}$	25.0	1.65
$^{16}O^{2-}$	37.6	2.48
$^{32}S^{2-}$	18.8	1.24
$^{40}Ca^{2+}$	15.0	.99
$^{55}Mn^{2+}$	11.4	.75
$^{56}Fe^{2+}$	10.8	.71
$^{59}Co^{2+}$	10.0	.66
$^{64}Zn^{2+}$	9.4	.62
$^{80}Se^{2-}$	7.6	.5

Table 6.2: The first columns give the cyclotron frequencies and cyclotron energies for biologically relevant bosonic ions in $B_{end} = .2 \times 10^{-4}$ Tesla. The third column gives cyclotron energy.

Bose-Einstein condensates of bosonic ionized atoms

The number of elements for which ions are bosons is not very large. **Table 6.2** lists the cyclotron frequencies of bosonic ions which are biologically important for $B_{end} = .2 \times 10^{-4}$ Tesla.

Table 6.2 inspires some comments.

1. For Li$^+$ the dominating isotope ^{7}Li$^+$ is fermion. ^{6}Li$^+$ is boson and its abundance is 5 per cent. Li$^+$ ions are used as medications in mania and represents mood stabilizer [J4]. A possible explanation is that the cyclotron oscillations of Bose-Einstein condensate of ^{6}Li$^+$ ions serve as a biological clock helping to stabilize the mood. The cyclotron frequency is however 50 Hz and higher than thalamocortical resonance frequency having nominal value 40 Hz.

   An alternative explanation for the effect of Li^+ is based on the observation that $^7Li_+$ has cyclotron frequency equal to 42.9 Hz for $B_{end} = .2 \times 10^{-4}$ Tesla, which is at the upper limit of the 40 Hz resonance band. The presence of lithium ions or their Cooper pairs could enhance thalamocortical resonance.

   These hypothesis could be tested by looking whether the use of pure $A = 6$ ($A = 7$) isotope of Li$^+$ amplifies the beneficial effect and the use of $A = 7$ ($A = 6$) isotope nullifies it.

2. For Mg^{2+} cyclotron energy corresponds to the energy of photon of green light. Chlorophyll is not able to convert nutrients to sugar without magnesium, which suggests that cyclotron transitions of Mg BE condensate are at least partially responsible for the green color of plants. Mg BE condensate could control the coherent occurrence of photosynthesis in the size scale of plant.

3. For oxygen ion the cyclotron frequency is 37.6 Hz and rather near to $\sim$ 40 Hz thalamocortical resonance frequency, which suggests that the cyclotron transitions of oxygen ions might play key role in inducing coherent firing of neurons at this frequency. This would mean that oxygen would be much more than a mere provider of metabolic energy. Note also that $\Delta n = 3$ cyclotron transition of Na$^+$ ion corresponds to frequency 39 Hz and might be involved with the synchronous firing.

4. Ca^{2+} ions play a unique role in the functioning of living matter. In particular, calcium waves appearing in a wide range of time scales are known to serve a crucial role in nervous system [J99]. Ca^{2+} corresponds to .99 eV cyclotron energy scale, which is twice the energy of metabolic energy quantum. Hence one can ask whether the cyclotron transitions of Ca^{2+} BE condensate could induce a collective emission of metabolic energy quanta and in this manner induce coherent metabolic activity in the scale of entire body.

5. The cyclotron frequencies Mn, Fe, Co, Cu, and Zn are in alpha band and corresponding cyclotron energies are somewhat above metabolic energy quantum. These energy quanta

Ion	f/Hz	E_c/eV
$^7Li_+$	42.9	
F^-	15.8	1.04
Na^+	13	.86
Al^+	11.1	.73
Cl^-	8.5	.56
K^+	7.5	.50
Cu^+	4.8	333.9
Ag^+	2.8	.18
I^+	2.4	.16
Au^+	1.5	.10

Table 6.3: The first columns give cyclotron frequencies and corresponding cyclotron energies for some ions in $B_{end} = .2 \times 10^{-4}$ Tesla for some fermionic ions.

could drive protons from larger space-time sheet to $k = 137$ atomic space-time sheet. 10 Hz frequency is known to define an important biological clock and Co ions could be essential for the functioning of this clock. $n = 3$ multiple of Co^{2+} cyclotron frequency corresponds to the 30 Hz threshold of gamma band known to be important for cognition. Also $3f_c(Fe^{2+}) = 32.2$ Hz and $3f_c(Mn^{2+}) = 34.2$ belong to gamma band. The presence of Bose-Einstein condensates of these ions in length scale of $5L(212) = 141$ km could mean that these bio-rhythms are shared by different organisms inside regions of this size.

6. The fact that the cyclotron frequency of Se^{2-} ion, which is known to be a biologically important trace element, corresponds to the nominal value of the metabolic energy quantum, raises the question whether Selenium BE condensate might act as a metabolic synchronizer.

Cyclotron frequencies and Schumann frequencies

Even in the case that Cooper pairs of fermionic ions are not thermally stable, the cyclotron transitions of fermionic ions like K^+, Cl^-, and Na^+ are expected to be important. In **Table 6.3** cyclotron frequencies and energies of some fermionic ions are given. Notice that the cyclotron energy of K^+ ion corresponds to metabolic energy quantum. Quite generally fermionic ions cannot be involved with the generation of Josephson part of EEG.

The first thing to notice is the close relationship of cyclotron frequencies with the lowest resonance frequencies in the spectrum of geo-electromagnetic field starting from 5 Hz, so called Schumann frequencies [F3], are $7.8, 14, 20, 26, 33, 39$ and 45 Hz. 5 Hz corresponds roughly to the threshold 4 Hz of theta frequency range below which EEG spectrum lies during sleep which suggests that wake-up state involves the coupling of brain with geo-electro-magnetic activity. 7.8 Hz corresponds to the threshold for alpha waves associated with wake-up state without cognition; 14 Hz corresponds to threshold of 13 Hz for beta waves accompanying cognitive activities, and 33 Hz is quite near to the threshold 30 Hz for gamma waves known to be important in the temporal coding of sensory data.

Consider now examples of cyclotron frequencies keeping in mind that Schumann frequencies vary typically within 1 Hz interval around their mean values [F3].

1. As already noticed, the frequencies, which are multiples of 15 Hz can be assigned to Ca^{2+} ion. The excitations $n = 3, 5, 7, ..$ correspond to the frequencies $45, 75, 105, ...$ Hz. All these frequencies have been observed. The two lowest frequencies correspond to Schumann frequencies 14 and 45 Hz with accuracy of 1 Hz.

2. Na_+ has $A = 23$ and gives $f = 13$ Hz. This is the lower bound for the frequency of beta EEG waves which are associated with conscious cognition. This would suggest that the presence of em field of 13 Hz frequency correlates with large fluxes of Na_+ ions through the axonal cell membrane during nerve pulse generation. This could result from increased amplitude of Na_+ Josephson current facilitating the emission of nerve pulses at the second half of the

EEG cycle. Silencing of mind by meditation or closing eyes reduces amplitudes associated with EEG frequencies below 13 Hz and conscious cognition disappears.

$n = 3$ excitation of Na_+ corresponds to 39 Hz, which is one of the Schumann frequencies and quite near to the 40 Hz resonant frequency associated with the thalamocortical circuit. This could correspond to jumping of Na_+ ions from ground state to $n = 3$ state or vice versa. $n = 5$ quantum jumps correspond to 65 Hz which is average EEG frequency during REM sleep! Thus 13, 39 and 65 Hz frequencies correspond to the basic signatures of conscious cognition. The two lowest transition frequencies correspond to Schumann frequencies 14 and 45 Hz within accuracy of 1 Hz.

3. K_+ has $A = 39$ and gives $f = 7.5$ Hz, which is theta frequency rather near to the lowest Schumann resonance frequency 7.8 Hz. K_+ ion flux could correlate with em fields in the range of the alpha frequencies creating cyclotron resonance. Theta activity dominates during sleep and Adey's observations [J30] demonstrate that 7 Hz ELF field increases reaction times. Second and third transition frequencies are within 1.5 Hz Schumann frequencies 20 and 37.5 Hz.

4. Cl_- ion has $A = 35$ and gives $f = 8.5$ Hz. Chloride ion has inhibitory effect. $n = 3, 7, ..$ excitations correspond to 25.5, 42.5 Hz, ... Rather interestingly, frequencies rather near to 40 Hz associated with thalamo-cortical loops appear as excitations for all ions relevant to nerve pulse activity. Note that 39 Hz is also Schumann frequency. Two lowest transition frequencies of Cl_- are quite near to Schumann frequencies 7.8 and 25 Hz.

5. Fe^{2+} has $A = 56$ and corresponds to 10.7 Hz. $3f_c(Fe^{2+}) = 32.2$ Hz is rather near to Schumann frequency 33 Hz whereas Co^{2+} corresponds to 10 Hz in excellent accuracy. Co has especially large nuclear magnetic moment and serves as a natural magnet. Fe^{2+} and/or Co^{2+} could be present in magnetic sensory organ possessed also by humans making it possible to navigate using magnetic fields. Yarrow suggests that Co makes B_{12} magnetic vitamin [J30] so that it can serve as fundamental biological clock at frequency very precisely equal to 10 Hz. Co is carried by B_{12} vitamin and is known to be important for normal consciousness: among other things the lack of B_{12} causes fatigue, blurred vision and cognitive problems.

6. Mg^{2+} has A=24 and $f = 25$ Hz which is near to Schumann frequency: $n = 3$ corresponds 75 Hz. Charged polypeptides could also form BE condensates and be involved with cyclotron mechanism: they are rather heavy and their cyclotron frequencies are in Hz range. Negatively charged organic molecules are indeed known to be present in neurons.

To sum up, surprisingly many magnetic transition frequencies are near to Schumann frequencies which suggests strong resonant interaction between brain and geo-electromagnetic fields.

What about proton's cyclotron frequency?

There are good reasons to expect that the cyclotron frequency of proton and its odd harmonics play an important role in brain functioning. The cyclotron frequency of proton in $B_{end} = .2$ Gauss is $f(p) = 300$ Hz. The frequency associated with $n = 3$ transition would be $3f(p) = 900$ Hz. Third harmonics of cyclotron frequencies of many ions with f_c in alpha band belong to gamma band known to relate to cognition. Perhaps this is true also in the case of proton.

The duration of single bit of the memetic codeword consisting of 127 bits and having total duration defined by the p-adic timescale $T^{(2)}_{M_{127}} = .1$ seconds corresponds to the frequency $f_m = 1027$ Hz. This frequency is by 10 per cent higher than the cyclotron frequency of proton for $B_{end} = .2$ Gauss. If magnetic homeostasis is realized, as will be discussed later, and if it allows 10 per cent variation of the strength of magnetic field as the width 1 Hz of alpha band suggests, it is possible to realize this frequency as proton's cyclotron transition frequency.

The frequency of neuronal synchronization, which is obviously associated with cognitive processing, is $\simeq 1$ kHz and might well be identifiable with f_m. The maximum rate of neuronal firing is slightly below kHz: this rate however corresponds to the rate of quantum jumps rather than oscillation frequency at space-time level.

Bose-Einstein condensates of bosonic molecular ions

Also biologically relevant bosonic molecular ions such SO_4^{2-}, CO_3^{2-}, NO_3^-, NO_2^- could form Bose-Einstein condensates. The cyclotron frequencies for bosonic molecular ions satisfying the thermal stability condition $A \leq 233 \times Z$ at room temperature are typically in theta and delta band and above $f_{min} = 1.29$ Hz.

DNA is negatively charged and an interesting question is whether DNA satisfies the stability condition. The molecular weights of DNA nucleotides A, T, C, G are 132, 126, 96, 149. The molecular weight of deoxyribose sugar attached to the nucleotide is 100 and that of phosphate group PO_4^{2-} is 95. Altogether this makes molecular weights 327, 321, 291, 344. Since phosphate group is doubly charged this structure has cyclotron energy which is higher than thermal energy. Also DNA sequences satisfy the thermal stability condition. The presence of DNA Bose-Einstein condensates at magnetic flux quanta could mean that DNA can be transferred between different organisms along these space-time sheets and that DNAs of different organisms of same species could form quantum coherent systems inside regions where magnetic field can be regarded as a constant.

6.5 About high T_c superconductivity and other exotic conductivities

During years I have been developing a model for high T_c superconductivity (see `http://tinyurl.com/b25sucr`). The recent view is already rather detailed but the fact that I am not a condensed matter physicist implies that professional might regard the model as rather lopsided. Quite recently I read several popular articles related to superconductivity and various types of other exotic conductivities: one can say that condensed matter physics has experienced an inflation of poorly understood conductivities. This of course is an fascinating challenge for TGD. In fact, super string theorist Subir Sachdev has taken the same challenge (see `http://tinyurl.com/hu4a27f`).

In particular, the article about superconductivity (see `http://tinyurl.com/h59yqn4`) provides a rather general sketch about the phase diagram for a typical high T_c super conductor and discusses experimental support for the idea quantum criticality in standard sense and thus defined only at zero temperature could be crucial for the understanding of high T_c super conductivity.

The cuprates doped with holes by adding atoms binding some fraction of conduction electrons are very rich structured. The transition from antiferromagnetic insulator to ordinary metal involves several steps described by a 2-D phase diagram in the plane defined by temperature and doping fraction. Besides high T_c super conducting region the phases include pseudogap region, a region allowing charge oscillations, strange metal region, and metal region.

In the following I consider the general vision based on magnetic flux tubes carrying the dark $h_{eff}/n = n$ variants of electrons as Cooper pairs or as free electrons allowing to understand not only high T_c super-conductivity and various accompanying phases but also exotic variants of conductivity associated with strange and bad metals, charge density waves and spin density waves. One could also understand the anomalous conductivity of SmB_6 [L28], and the fact that electron currents in graphene behave more like viscous liquid current than ohmic current (see `http://tinyurl.com/jlgd2we`).

The TGD inspired model for the anomalous conductivity of SmB_6 as flux tube conductivity developed during last year [L28] forms an essential element of the mode. This model implies that Fermi energy controlled by the doping fraction would serve as a control variable whose value determines whether electrons can be transferred to magnetic flux tubes to form cyclotron orbits at the surface of the tube. Also the metals (such as graphene) for which current behaves more like a viscous flow rather than Ohmic current can be understood in this framework: the liquid flow character comes from magnetic field which is mathematically like incompressible liquid flow.

6.5.1 The phase diagram and observation

The popular article "The Quantum Secret to Superconductivity" (see `http://tinyurl.com/h59yqn4`) tells about an article published in Nature [D16] (see `http://tinyurl.com/go9k8cs`)

about the work of a group o researchers at the National Laboratory for Intense Magnetic Fields (LNCMI) in Toulouse, France led by Cyril Proust and Louis Taillefer.

The popular article contains a phase diagram, which gives a bird's eye of view about high T_c superconductors and provided the stimulus for this article. The diagram describes the phases of a doped cuprate (now yttrium barium copper oxide superconductor $YBa_2Cu_3O_7$, see `http://tinyurl.com/ycpscdfe`). Doping means an addition of impurities, which bind electrons and lead to the formation of holes. Also electron doping is possible. The diagrams contains several regions representing phases of the system.

The diagram (see **Fig. 6.1**), which probably should not be taken too literally, can be seen as a qualitative representation of the phase transition sequence leading from an antiferromagnetic insulator to a conducting metal. It is considerably more complex than the corresponding diagram for the ordinary insulator metal transition. One starts from un-doped antiferromagnetic insulator and increases the doping fraction and ends up with metal. The holistic strategy is to try to understand all transitions and phases appearing in the entire diagram using same basic model rather than the mere transition to super-conductivity.
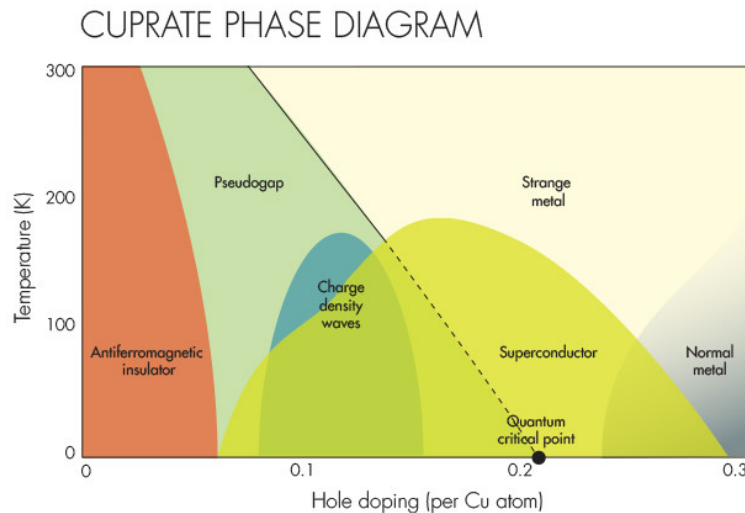
Figure 6.1: The phase diagram of typical high T_c superconductor

1. Above temperature dependent critical doping around $d = .05$ (meaning addition of impurities) a transition to so called pseudogap phase occurs. At a higher temperature dependent critical doping ratio varying in the range $(.05, .14)$ emerges a hill representing high T_c superconductivity.

2. There is also a parabola shaped region bounded at the top of super-conducting hill in which charge density wave define the ground state. In his phase kind of jerkwise conductivity but not yet superconductivity occurs. The piece of parabola is contained in doping fraction interval between $(.08, .13)$ (reader might disagree, I apologize for my bad eye sight).

3. At temperature above 170 K and for temperature depending doping ratio decreasing with temperature linearly pseudogap is transformed to a strange metal bounded by superconductor hill below. Farthest to the right is the ordinary metal phase bounded by superconducting hill and strange metal region. Critical doping fraction for the transition from superconductivity to ordinary conductivity decreases with temperature and is in the range $(.26, .29)$.

The challenge is to understand what these regions correspond physically and what happens in the transitions between them. The crucial observation is following. The researchers realized that the line representing the boundary between pseudogap and strange metal seems to continue

below the super-conducting regions. Could one destroy the superdonducting region to see whether it meets the $T = 0$ axis at the bottom and could at this point quantum phase transition occur at critical value of doping?

This was done by putting the system to a strong magnetic field of 90 Tesla destroying the superconducting phase by making Cooper pair unstable. It was indeed observed that the number of holes per Cu atom - called charge carrier density (perhaps misleadingly) - increased by a factor 6 at this critical point - actually in its vicinity since $T = 0$ is not reachable exactly. The researchers think that this might be crucial guideline in attempts to understand high T_c superconductivity and I share their belief. The understanding of what really happens in the transition to super-conductivity or rather in the transition from the pseudogap state to super-conductivity is the problem.

6.5.2 Alternative proposals for the mechanism of superconductivity

What has been observed is quantum critical point at $T = 0$ at which the density of holes per atom increases by a factor of 6. This does not mean that the superconducting charge carriers are Cooper pairs of holes. The phenomenon might have nothing to do with superconductivity in superconducting phase. The phenomenon is observed by using strong magnetic fields preventing superconductivity so that one in principles does not study the same system anymore.

Several hypothesis for the mechanism of super conductivity have been proposed and some of them are mentioned in the popular article (see `http://tinyurl.com/h59yqn4`) .

1. Spin density waves (mentioned in Wikipedia article but not discussed in the popular article) would take the role of phonons and induce the formation of Cooper pairs by a kind of water bed effect. These waves do not appear in the phase diagram. Now the Coulomb repulsion forces the members of Cooper pair to reside at different lattice sites and the outcome would be d-wave Cooper pair having a note at origin. In TGD the members of Cooper pair at parallel flux tubes so that also now d-wave is obtained for spin singlet state and p-wave for spin triplet.

2. Charge density wave fluctuations would somehow be involved with the formation of Cooper pairs. Phase diagram for charge density fluctuations does not support this picture since the superconducting regions is much larger. Transitions to superconductivity can happen from 4 regions: pseudo gap region, the regions with fluctuating charge density, strange conductor, and ordinary conductor. Also spin density wave fluctuations could have similar role.

3. A phase transition occurring to the anti-ferromagnetic phase is suggested to somehow induce the formation of Cooper pairs. The called Merlin-Wagner theorem stating the absence of breakdown of continuous symmetry in two-dimensional models of statistical physics at non-zero temperatures does not support this hypothesis. One could circumvent this problem by assuming that only patches forming kind of checkerboard consisting of super-conducting and non-superconducting regions can develop in 2-D. No checkerboards have been observed. Note that there is however an objection against Merlin-Wagner theorem. Antiferromagnetic order has been detected in undoped cuprates with the same 2-D structure.

Subir Sachdev is a super string theoretician, who has been developing superstring inspired methods - in particular AdS/CFT correspondence - to study quantum critical phenomena. Sachev and collaborators have developed methods for studying "strange metals". These systems are exceptional in that they do not have any quasiparticle excitations. Sachev has correctly predicted charge density fluctuations in high T_c superconductors and also proposed that the precursor for high T_c superconductivity would be what he calls fractionized Fermi liquid meaning fractional spin and charge. One would have something like ordinary conductivity but with fractional charges. This phase could correspond to strange metal.

6.5.3 TGD proposal for the mechanism of high T_c superconductivity

The challenge for TGD inspired qualitative model is to understand these phases in terms of magnetic flux tubes and dark electrons possibly forming Cooper pairs at them.

Formulation of the model

The starting point is the model developed hitherto.

1. Consider first Merlin-Wagner theorem as an objection against breaking of 2-D continuous symmetries. TGD suggests however a mechanism allowing a breakdown of 2-D continuous symmetries (by strong form of holography TGD space-time is almost 2-D as far as scattering amplitudes are considered: string world sheets and partonic 2-surfaces). The continuous symmetries in question include supersymplectic transformations having conformal structure meaning that the generators are labelled by conformal weights which come as integer multiples of generating weights. This symmetry breaking would lead from the original symmetry algebra to its sub-algebra isomorphic with the original. Just a zoom up of the original symmetry would be the outcome! Maybe Merlin and Wagner could tolerate this!

   Now one would have something different from a checkerboard of patches. There would be quantum critical phase in which a phase containing Cooper pairs at short flux tubes with Planck constant $h_{eff}/h = n_1$ and phase containing long flux tubes with $n_2 > n_1$ but no Cooper pairs at them. There would be fluctuationS between these phases. Fluctuation would have in ZEO as correlate space-time surface connecting three surfaces at opposite boundaries of CD such that the values of n would be different at them [L41] (see `http://tinyurl.com/y7znls3j`).

2. The earlier model [L30] (see `http://tinyurl.com/yaoghft8`) identifies the pseudogap as quantum fluctuating phase in which there isA competition between short and long flux tubes pairs related by re-connections for short flux tubes containing Cooper pairs such that their members are at parallel flux tubes of pair carrying magnetic fields in opposite direction. Long flux tubes canot carry Cooper pairs and this together with fluctuations spoils macroscopic super-conductivity in pseudogap phase and makes it a poor conductor.

   Pseudogap is present in the density of states since part of electrons goes to the short flux tubes. The transition to superconducting phase identified in terms long flux tubes carrying Cooper pairs would occur when Cooper pairs go also to the long flux tubes and would be analogous to the percolation phase transition in which water begins to dribble through a sand layer. Pseudogap phase is quantum critical: zero energy ontology (ZEO), which allows to see quantum theory as a square root of thermodynamics at single particle level indeed allows quantum criticality also at non-vanishing temperatures.

3. Strange metal phase can be identified as a phase in which only short super-conducting flux tubes are present and carry supra currents but in short scales only. Since Cooper pairs have spin zero, the charged currents do not carry spin: this conforms with the observation that the resistance for spin currents has different temperature dependence than for charged currents. Therefore the generalization to 2-D case of the charge-spin separation possible in 1-D case (but also in this case non gauge-invariant notion, (see `http://tinyurl.com/znsver8`) is not needed. Quite generally, the possibility of short scale $S = 0$ super conductivity could explain the charge-spin separation.

   The fact that scattering leads from dark phase at flux tubes to ordinary phase could explain the linear temperature dependence of the resistance of strange metals. In ordinary metals the dependence is quadratic: the reason is that the number of initial and final state electrons is proportional to T. If the number of dark Cooper pairs at flux tubes does not depend on temperature one obtains linear dependence.

   The absence of quasiparticle excitations in strange metal would be due to the fact that Cooper pairs are dark and at magnetic flux tubes. Both n_1 and $n_2 > n_1$ phase would be present below critical doping fraction in the experiment discussed and would correspond to a situation in which there is a fluctuation between the short length scale superconductivity and long length scale flux tubes not containing Cooper pairs. The strong magnetic field used in the experiment would not destroy the long flus tubes and the quantum critical phase would survive.

4. The quantum critical phase transition discussed in the article at zero temperature and critical doping fraction increases the number of holes per copper atom by a factor 6. Also this can

be understood qualitatively. The transfer of electrons to dark Cooper pairs generates holes. In pseudogap region the long flux tubes do not carry Cooper pairs. As the phase transition occurs, only short flux tubes remain and accept pairs maximal number so that the number of holes per copper atom increases. Also the properties of pseudogap can be understood. Pseudo gap means a low density of states at certain points of Fermi surface (the point defines a preferred direction of current) and is known to be only in direction parallel to CuO bonds: this can be understood if flux tubes are parallel to them.

Charge density waves and spin density waves and their fluctuations

Can TGD say something interesting about charge density waves (see `http://tinyurl.com/y9g7t34j`) and spin density waves (see `http://tinyurl.com/y97vmya7`)?

1. Charge density wave defines a ground state of the system having lower energy than the state with constant density of electrons. These waves are periodic standing waves with wavelength $\lambda = \hbar/k_F$. Wavelength does not in general correspond to a multiple of lattice constant. In presence of these waves conduction occurs in random jerkwise fashion like the water dribbling from faucet. The standard explanation for the jerkwise current is that the charge density wave is in a potential well caused by defect and when the electric field exceeds the critical value it is released and slides generating an ohmic current. Below the threshold the system would behave as an insulator.

2. Spin density waves are very similar to charge density waves: instead of charge, the direction of spin varies in oscillatory manner with wavelength defined by Fermi wave vector in ground state. Also now a current is formed in direction of the magnetic field above critical value of magnetic field. Sliding mechanism is proposed also now as the underlying mechanism of conductivity.

3. The key question is where a spatially varying fraction of charge/spin goes as charge/spin density wave is formed. In TGD Universe the answer would be rather obvious: "To flux tubes!". Both charge density wave and spin density could involve a sequence of magnetic flux loops with a period defined by k_F so that supra currents could flow below this length scale. Charge density wave could result from a transfer of electrons to flux tubes producing oscillator charge density at the flux tube inducing corresponding charge density oscillation in lattice. In the case of spin density wave the spin directions would be correlated at flux tubes and induce corresponding correlation in the lattice.

4. The conductivity associated with charge density wave above critical electric field could correspond to a kind of premature and temporary phase transition to super-conducting phase in which long flux tubes contain Cooper pairs but are still unstable. In the transition to superconductivity a reconnecting to long flux loop looking like long and thin rectangle would be formed by reconnections. One would have a system fluctuating between short and long scale superconductivities. One could of course consider also sliding of the flux tubes but this does not seem so plausible option in TGD framework.

   The conductivity induced by critical magnetic field could be understood if the magnetic field induced a phase transition reconnections transforming the periodic short flux tube structure to a pair of long flux tubes. Why the magnetic field would induce this, is not clear. Same question of course applies in the case of the critical electric field inducing the generation of current in charge density wave.

The role of doping fraction

Can one understand the role of doping fraction?

1. The number of holes per copper atom depends on the doping fraction. The holes would be created when dark Cooper pairs are generated. If the density of dark Cooper pairs increases dramatically at critical doping fraction, the density of holes must increase. Somehow the over-critical doping fraction would favor the formation and stability of short dark flux tubes. Maybe it becomes energetically more favorable for electrons to go to flux tubes. This might

relate to cyclotron energy proportional to h_{eff} at flux tubes and Fermi energy E_F: a kind of resonant transfer suggests itself.

For some time ago I constructed a model for the anomalous conductivity of SmB_6 in external field in terms of Haas-van-Alphen effect for non-standard value of h_{eff} [L28] (see `http://tinyurl.com/y8oblpl9`). A resonant transfer of electrons to flux tubes occurs if the energy energy at the surface of the Fermi sphere corresponds to energy for a cyclotron orbit at the surface of the flux tube. The largest orbit at Fermi sphere would be at the surface of the flux tube. This implies the occurrence of Haas van Alphen as a periodic dependence of magnetization on the value of external magnetic field $1/B$ and also explains also the anomalous conductivity of SmB_6 as flux tube conductivity occurring when the resonance condition is satisfied.

A rather natural expectation is that same happens now. The doping fraction would control the value of Fermi energy, and this in turn would control the rate for the leakage of electrons to Cooper pairs at flux tubes by resonance condition. If the dependence of the Fermi energy on doping fraction is slow this could allow to understand why an entire range of doping fractions is possible. That the electrons must have Fermi energy must correlate with the wave length of of charge and spin density waves. The length of the short flux tube loop corresponds to Fermi wave vector.

There is also a feedback effect involved. When electrons become Cooper pairs at short flux tubes, their density in lattice is reduced and this reduces Fermi energy so that resonance condition might fail to be satisfied. If flux tubes carry monopole flux, flux is quantized and the value of the magnetic field depends on the thickness of the flux tube, which could also be dynamical.

2. Below critical doping fraction long flux tubes would be possible but would be unstable and unable to carry stable Cooper pairs. The reason could be that the resonance condition for the transfer fails to be satisfied (the thickness of long flux tubes would not satisfy the resonance condition). Superconductivity and strange metal property would disappear above certain temperature dependent value of the doping fraction. Also this could be understood in terms the failure of the resonance condition for both short and long flux tubes. In the charge density wave region the resonance condition would be satisfied for the long flux tubes.

Connection with Sachdev's ideas

Sachdev's ideas mentioned above have correspondences in TGD. AdS/CFT is central in Sachev's approach and it has been also proposed as a solution of so called sign problem (see `http://tinyurl.com/h9ogjjd`) plaguing QFT models and statistical physics models in dimension $D \geq 3$. Sign problem gives one additional good reason for the localization of the induced spinor fields at 2-D string world sheets in TGD framewwork [K124].

1. AdS/CFT relies on conformal symmetry: in TGD framework the conformal symmetry is generalized to super-symplectic symmetry and other symmetries having conformal structure and assignable to the boundary of light-cone and to the light-like orbits of partonic 2-surfaces at which the induced metric changes its signature from Minkowskian to Euclidian.

2. TGD Universe is quantum critical so that also this aspect is shared. AdS/CFT correspondence relies on holography: in TGD framework one has strong form of holography and one can say that the 10-D bulk is replaced with 4-D space-time surface in $M^4 \times CP_2$.

3. Charge and spin fractionization are plausible also in TGD: the unit would be scaled down by $1/n$ ($h_{eff}/h = n$) and in twistorial approach [K49] this is understood quite satisfactorily.

4. Also in TGD the precursor would be strange metal. I have already explained how charge spin separation reflecting itself as different temperature dependences of resistances for charged and spin currents and the linear dependence of resistivity on temperature can be understood.

There are also differences. In TGD framework strange conductor would be flux tube super-conductor in short length scales with $h_{eff}/h = n_1 < n_2$ rather than fractional ordinary conductor.

Bad and strange metals and metals behaving like water

Besides high T_c superconductors there are also other exotic conductors such as strange and so called bad metals http://tinyurl.com/zzzyenp) difficult to understand using the ideas of existing condensed matter physics.

In the case of bad metals (see http://tinyurl.com/k54k9oa) the conductivity is low but is preserved to too high temperatures. The problem is that if the electrons scatter as usual the time τ between collisions becomes too small and at higher temperatures Uncertainty Principle requiring $T \times \tau \geq h$ fails to be satisfied. Quite recent proposal [D28] is that current carrying electrons somehow disappear and this fluctuation is not only responsible for low but on-vanishing conductivity. These fluctuations could be due to the quantum critical fluctuations transforming electrons to Cooper pairs at short flux tubes. Bad metal would be unable to decide whether to be an insulator or strange metal.

Also graphene behaves in a strange manner (see http://tinyurl.com/hffdl8s) in the sense that currents behave more like viscous liquid flow rather than ohmic currents. The presence of vortices is a basic signal about this. A model assuming a negative resistance allowing electrons to move in "wrong direction" in electric field is considered as an explanation. To me this option looks tricky.

Liquid like behavior might be understood if the currents flow at magnetic flux tubes. Magnetic field is mathematically analogous to an incompressible liquid flow. Flux tubes would be like water pipes forming a network and the topology of the ohmic currents would reflect the topology of this loopy magnetic network. The direction of the electric field inside flux tube space-time sheet would be parallel to the flux tube so that negative resistance would not be required: electric field would change direction locally rather than resistance its sign. In long scales at the space-time sheets assignable to the ordinary matter the direction of electric field would be constant. The phenomenon would reflect many-sheetedness of space-time lost in the gauge theory limit of TGD. Note that if currents are supra currents along flux tube pairs in short scales, there would be no resistivity in these scales.

To sum up, the notions of magnetic flux tube and dark matter hierarchy suggest common mechanisms for all the exotic conductivities. From this it is of course a long way to quantitative models.

6.5.4   New findings about high-temperature super-conductors

Bozovic *et al* have reported rather interesting new findings about high T_c super-conductivity: for over-critical doping the critical temperature is proportional to the density of what is identified as Cooper pairs of electronic super-fluid. Combined with the earlier findings that super-conductivity is lost - not by splitting of Cooper pairs - but by reduction of the scale of quantum coherence, and that below minimal doping fraction critical temperature goes abruptly to zero, allows to add details to the earlier TGD inspired model of high T_c super-conductivity. The super-conductivity would be indeed lost by the reconnection of flattened square shaped long flux loops to shorter loops of pseudogap phase. Quantum coherence would be reduced to smaller scale as h_{eff} is reduced. Transversal flux tube "sound waves" would induce the reconnections. Electrons at flux loops would stabilize them by contributing to the energy density and thus to the inertia increasing the string tension so that the average amplitude squared of oscillations is reduced and critical temperature increases with electron density.

Results

A popular article in Phys.org (see http://tinyurl.com/htr2qjj) tells about new interesting results about high T_c superconductivity. Bozovic *et al* have published in Nature an article titled *"Dependence of the critical temperature in overdoped copper oxides on superfluid density"* (see http://tinyurl.com/gqo9j67) [D18]. The abstract of the article gives first glimpse about the work.

> *The physics of underdoped copper oxide superconductors, including the pseudogap, spin and charge ordering and their relation to superconductivity is intensely debated. The overdoped copper oxides are perceived as simpler, with strongly correlated fermion physics*

evolving smoothly into the conventional Bardeen–Cooper–Schrieffer behaviour. Pioneering studies on a few overdoped samples indicated that the superfluid density was much lower than expected, but this was attributed to pair-breaking, disorder and phase separation. Here we report the way in which the magnetic penetration depth and the phase stiffness depend on temperature and doping by investigating the entire overdoped side of the La2xSrxCuO4 phase diagram. We measured the absolute values of the magnetic penetration depth and the phase stiffness to an accuracy of one per cent in thousands of samples; the large statistics reveal clear trends and intrinsic properties. The films are homogeneous; variations in the critical superconducting temperature within a film are very small (less than one kelvin). At every level of doping the phase stiffness decreases linearly with temperature. The dependence of the zero-temperature phase stiffness on the critical superconducting temperature is generally linear, but with an offset; however, close to the origin this dependence becomes parabolic. This scaling law is incompatible with the standard Bardeen–Cooper–Schrieffer description.

I do my best in order to understand what this says. The Wikipedia article (see `http://tinyurl.com/b25sucr`) helps to get overall view about high T_c superconductivity. The Phys.org article (see `http://tinyurl.com/htr2qjj`) gives first clues in attempts to understand what the abstract says. The earlier article of Bozovic *et al* (see `http://tinyurl.com/hk88h5w`) [D17] stating that the loss of super-conductivity does not mean splitting of Cooper pairs but loss of quantum coherence or rather its reduction to shorter length scale gives additional insights.

In the following I proceed by self-Socratean method by making questions and bringing in the TGD view based on quantum criticality and magnetic flux tube pairs as carriers of members of Cooper pairs responsible for the supra current.

Basic notions

I try first to understand the notions of doping and phase stiffness.

1. In the work under discussion [D18] overdoped cuprate superconductors were studied. Doping by holes and electrons is possible. Underdoped superconductors are studied and are not well-understood. Superconductivity appears in some range for the values of the doping fraction: the minimal doping is typically something like .05 for holes and .2 for electrons from the diagram of Wikipedia article.

   "Overdoping" is achieved by the addition of strontium atoms as impurities. It had been already known that overdoping induces a reduction of the density of electron pairs and that critical temperature is reduced as a consequence. In the experiments discussed the critical temperature was found to depend linearly on the density of what was identified as super-fluid electron pairs linearly and going to zero as the doping fraction increases. In TGD pairs would correspond to small scale super-conductivity.

   There is also the notion of self-doping, see the popular article titled "*Self-doping may be the key to superconductivity in room temperature*" at `http://tinyurl.com/jxrdagm` telling about the article of Magnuson *et al* [D32] (see `http://tinyurl.com/zvfhqu2`). There are mysterious chains between the lattice planes of cuprate carrying negative charge. Self doping means that the system itself generates them and controls the charge density at them. Could these chains be associated with the flux tube pairs carrying the Cooper pairs in TGD framework?

2. Phase stiffness refers to the phase of a complex order parameter (see the article "*Weak phase stiffness and nature of the quantum critical point in underdoped cuprates*" of Yildrim and Ku at `http://tinyurl.com/yauzaz6r`), which might correspond to that assignable to the short range super-conductivity (or superfluidity as authors identify it). One poses twisted boundary conditions forcing the phase to vary spatially. How this is done, I do not understand.

   The phase stiffness corresponds to energy density forced by these boundary conditions. In lowest order approximation energy density is proportional to the square of the gradient of the phase and coefficient is analogous to string tension. This parameter is proportional the density of Cooper pairs theoretically. The strange thing is that phase stiffness goes to zero

below the minimal doping rather than going to zero smoothly. In overdoped region the phase stiffness at zero temperature limit was found to depend linearly on the critical temperature.

TGD based model for the findings

TGD inspired model for high T_c superconductivity and bio-superconductvity have been developed gradually during two decades [K25, K26, K89, K90] [L30, L32]. The new results allow to add new details to this model, in particular to the understanding of what happens when the superconductivity is lost.

1. The popular article says that the critical temperature is controlled by the 2-dimensional density of electron pairs identified as super-fluid Cooper pairs. They would correspond to the so called pseudogap phase. An important point is that super conductivity is not lost due to the breaking of Cooper pairs as in the ordinary super-conductivity but due to too small value of the density of electron pairs: this is also the TGD view. In an earlier work to which Bojovic also contributed it is claimed that super-conductivity is lost due to the loss of quantum coherence rather than splitting of Cooper pairs [D17] (see http://tinyurl.com/zmbeynz).

   Both these findings conform with the TGD view that transition to super-conductivity means a phase transition increasing the value of h_{eff} increasing the range of quantum coherence scaling like h_{eff}. Cooper pairs exist also in pseudogap phase and can have non-standard value of h_{eff} but the closed flattened square shaped flux loops along which the members of pairs flow are too short to give rise to super-conductivity in macroscopic scales. in TGD framework the electron super-fluid about which the article talks would correspond to short scale superconductivity.

   The density of Cooper pairs for small value of h_{eff} identified by authors as super-fluid carriers would be the critical quantity: for some range of this parameter the h_{eff} increasing phase transition would take place. This range would in turn correspond to a range for the energy assignable to the pair if the energy is proportional to 2-D Fermi energy.

2. This allows to consider TGD based model of high T_c super-conductivity in which Cooper pairs have their members at parallel magnetic flux tubes closing to a loop and carrying magnetic fluxes in opposite direction in the case of antiferromagnet. In pseudogap phase the pairs would have their members at the flux tubes with opposite spin directions. In the phase transition to superconductivity the value of h_{eff} would increase and the flux tubes would reconnect to much longer flux tubes and macroscopic super current would flow.

3. What happens in the phase transition increasing h_{eff} giving rise to superconductivity in macroscale? The lengths of closed flux loops are scaled up in reconnection. Longitudinal energy is not affected. It seems that the transversal distances between flux tubes cannot change.

   What happens to the strength of magnetic field? Is should be reduced to keep cyclotron energy proportional to $h_{eff}B$ constant? For monopole flux, flux conservation requires that magnetic flux BS does not change so that the area S of the flux tube would scale like h_{eff}. That cyclotron energy is not changed at all would conform with the intuition about quantum criticality.

4. Why the phase trasition to larger h_{eff} phase occurs only above the critical temperature? Why these flux loops are unstable against reconnection above critical temperature? Cooper pairs do not split but reconnection splitting long closed flux loop to a sequence of shorter ones takes place.

   Some energy assignable to large h_{eff} flux tubes is reduced below the thermal energy above critical temperature and a transition to small h_{eff} phase. In reconnection process the parallel flux tubes with opposite fluxes touch each other. This touching occurs if there are oscillations of flux tubes in transversal direction analogous to transversal sound waves.

   Does the average amplitude of transversal "sound waves" become so large above critical temperature that reconnections occur? This brings in mind ordinary BSC superconductivity in which phonon-electron interaction makes possible formation of Cooper pairs as bound

states. Phonons for the ordinary super-conductvity however corresponds to lattice oscillations and make superconductivity possible. Now just the opposite happens.

5. What the proportionality of T_c to the density of small Cooper pairs could mean? The energy of transversal phonon is proportional to its amplitude squared. If the amplitude and thus energy is above critical value the reconnection occurs.

   Why the critical thermal energy increases with the density of small Cooper pairs? Does the presence of Cooper pairs stabilize the flux tubes: for too small density flux tubes are not stable since their string tension is too low and they are too soft and have large amplitude of thermal fluctuations.

   Does the presence of Cooper pairs increase the inertia of flux tubes and therefore their string tension? The hermal energy of stringy sound waves proportional to critical temperature becomes proportional to electron density if the electron density dominates in string tension. This would explain also the lower critical value for the doping fraction. Below it flux tubes become so soft that reconnection occurs too fast to allow super-conductivity at all. Above pseudogap temperature even the short loops would become unstable.

What we have obtained? In TGD framework the super-conductivity is not spoiled by the splitting of Cooper pairs but by the reconnection of flattened square shaped long flux loops. Super-conductivity is lost by the reconnection of flattened square shaped long flux loops to shorter loops of pseudogap phase, which is super-conducting but in smaller scale. Transversal flux tube "sound waves" induce the reconnections. Electrons at flux tubes stabilize them by contributing to the energy density and thus to the inertia increasing the string tension so that the average amplitude squared of oscillations is reduced and critical temperature increases with electron density.

6.6 Self Hierarchy And Hierarchy Of Weakly Coupled Super Conductors

The realization that bio-systems are full of macroscopic quantum phases led to the general idea about the dynamical realization of the self-hierarchy as a master-slave hierarchy formed by weakly coupled super conductors. It is now clear that mere Josephson currents are not enough: the breaking of super-conductivity due to leakage of supra currents from the super-conducting space-time sheets might also be an essential part of bio-control. A possible general conclusion is that Josephson currents are responsible for coordination whereas dissipative currents are related with the control aspect. The idea about charge entanglement made possible by W MEs and generating the dissipative currents makes this vision more precise.

One of the great ideas was that soliton sequences associated with the Josephson currents underly nerve pulse sequences. This idea turned out be be wrong as such: as a matter, soliton sequences correspond to various bio-rhythms such as kHz resonance frequency and various EEG rhythms in the recent model and nerve pulses could be understood as a perturbation of this sequence when rotational motion of some pendulum in the sequence of penduli becomes oscillatory. Since homeostasis as a many-sheeted ionic flow equilibrium involves also Josephson currents in an essential manner, it would be however light hearted to assume that Josephson currents and the dynamics at the level of cell membrane were totally uncorrelated. The model for sol-gel phase transition indeed demonstrates that Josephson currents generate Josephson photons crucial for stabilizing gel phase.

The hierarchy of favored Planck constants predicted by the Mersenne hierarchy implies a hierarchy of Josephson junctions defined by cell membranes and the value of Planck constants defines the evolutionary level of cell. As already noticed, EEG radiation and its fractal generalization and bio-photons can be identified as decay products of dark Josephson radiation in the case that the cell membrane space-time sheet is almost vacuum extremal. The frequency of the possible Josephson currents associated with the atomic space-time sheets of the cell membrane (or some larger space-time sheets with the same potential difference by the average many-sheeted ir-rotationality of the cell membrane electric field) corresponds in the resting potential of about -70 mV. For almost vacuum extremal option the Josephson currents could define bio-rhythms in

extremely wide range from 10^{-15} s time scale to time scales comparable to the duration of life cycle.

Also hierarchies with levels characterized by the size scale of the membrane like structure involved can be considered but experimentally the situation remains open. Potential differences are in any case limited by the condition that Josephson energies are above thermal threshold. One possibility is that pairs or parallel super-conducting magnetic flux tubes form Josephson junctions. Indeed, at the higher levels of dark matter hierarchy one obtains both time-like and space-like soliton sequences and their Lorentz boosts.

What remained open in the earlier picture was the relationship between Josephson current circuitry and EEG, and nerve pulse generation and the possible analogs of EEG, ZEG (and WEG) and nerve pulse generation in various other frequency scales. The possibiity of generalized EEG hierarchy associated with dark matter hierarchy lead to a general quantitative picture in this respect and allows to interpret the components of generalized EEG in terms of cyclotron radiation and Josephson radiation as a response to cyclotron radiation. The general manner to code information about sensory input and motor actions is in terms of frequency modulation of the EEG frequencies defining EEG rhyths. A fascinating possibility is that scaled up variants of nerve pulses with typical time scale of about 2 seconds instead of millisecond associated with say neuronal bi-layers are realized in higher vertebrates. At the next level the "nerve pulses" would have duration of order 1.1 hours.

Supra currents running parallel to the axon suggest an important additional piece to the picture about of quantum control. Constructive interference of supra currents leads to a large net Josephson current and various biological clocks could rely on this mechanism. When reference supra current representing the expected sensory input and a current representing real sensory input and flowing in parallel manner in weakly coupled super conductors, are sufficiently near to each other, constructive interference of the Josephson currents occurs and can give rise to a synchronous firing. This makes possible conscious comparison circuits. Conscious novelty detectors can be build easily from comparison circuits using inhibitory and excitatory synaptic connections.

It must be emphasized that detailed models cannot be taken too seriously. There are simply quite too many new physic mechanisms to be considered. The following considerations actually represent the first general vision about the role of super conductivity in living matter, and also this is a good reason for not taking them too literally. As in the case of other similar sections, I have made the decision to keep it as such since the general vision might apply also in the recent framework although it failed in the original model of nerve pulse and EEG. The replacement of the representation of Josephson junction by magnetic flux tubes carrying dark variants of electrons and ions might provide a general realization of the vision. For instance, standing wave solitons associated with the Josephson currents between cytoskeletal microtubules and regions of the cell membrane could be involved with DNA - cell membrane TQC. These currents - at least in the case of axons- might be also responsible for ordinary EEG (note that a hierarchy of fractal variants of EEG are predicted [K44].

6.6.1   Simple Model For Weakly Coupled Super Conductors

Several kinds of Josephson currents between cell interior and exterior are possible. Solitons represent quantized Josephson currents which are large and able to facilitate the generation of nerve pulse in the case of Na_+ and Ca_{++}. Soliton sequences are the simplest solutions of Sine-Gordon equation for the Josephson junctions associated with a linear structure such as axon idealized as an infinitely long and thin cylindrical surface and are mathematically equivalent with a rotating gravitational pendulum.

The most general formulation starts from the Klein-Gordon equation for the order parameters Ψ_i, $i = 1, 2$ for the super-conductors coupled linearly to each other in the junction

$$
\begin{aligned}
D\Psi_1 &= m^2\Psi_1 + m_{12}^2\Psi_2 \ , \\
D\Psi_2 &= m^2\Psi_2 + m_{12}^2\Psi_1 \ , \\
D &= (\partial_\mu + iZeA_\mu)(\partial_\mu - iZeA_\mu)
\end{aligned}
\tag{6.6.1}
$$

Here m denotes the charge of the super-conducting particle (say Cooper pair) and m_{12}^2 is real

parameter characterizing the coupling between the super conductors. A_μ denotes electromagnetic vector potential associated with the super conductors. D denotes d'Alembert operator $\partial_t^2 - \nabla^2$.

Weakly coupled super conductors are assumed to possess cylindrical symmetry and can regarded as inner and out cylinder with Josephson junctions idealized with smooth distribution of them. If ME acts as Josephson junctions this assumption is exact. Weak coupling means that that the densities of charge carriers are same at the two sides of the junction in a good approximation:

$$\Psi_i = \sqrt{n} exp(i\Phi_i) \ , \ i = 1, 2 \ . \tag{6.6.2}$$

Under these assumptions one obtains for the phase difference $\Phi \equiv \Phi_1 - \Phi_2$ the Sine-Gordon equation with a coupling to the vector potential

$$\partial^\mu \left[\partial_\mu \Phi - q\Delta A_\mu \right] = m_{12}^2 sin(\Phi) \tag{6.6.3}$$

ΔA_μ denotes the difference of the vector potential over the junction. q denotes the charge of the super-conducting charge carrier.

Note that Lorentz gauge condition

$$\partial_\mu A^\mu = 0 \tag{6.6.4}$$

does not trivialize the coupling to the vector potential since the equation holds true only in 3-dimensional surface defining the junction and the contribution from the direction of the normal is not present.

Josephson current J_J can be identified as the divergence of the 4-current $j_\mu = Ze\rho = Ze\Psi^*(\partial_\mu^\rightarrow - \partial_\mu^\leftarrow)\Psi$ at the either side of the junction.

$$J_J = \partial_\mu J^\mu = Ze \times \frac{n}{m} \times m_{12}^2 sin(\Phi) \ . \tag{6.6.5}$$

The Josephson current per unit length of axonal membrane of radius R and thickness d is given by

$$J = Ze \times \frac{n2\pi Rd}{m} \times m_{12}^2 sin(\Phi) \ . \tag{6.6.6}$$

The parameter m_{12}^2 is analogous to the inverse of the magnetic penetration length squared ($\hbar = c = 1$) for the super-conductors involved.

$$m_{12}^2 = \frac{1}{\Lambda^2} \ . \tag{6.6.7}$$

If one can regard the Josephson junction region as a defect in a super-conductor, Λ is apart from a numerical constant of order unity equal to the thickness of the Josephson junction. In the case of the cell membrane this would mean that the small oscillations associated with the Josephson junction have frequencies of order 10^{16} Hz and correspond to quanta with energies of order 100 eV.

The covariant constancy conditions

$$\partial_t \Phi = ZeV(t, z) \ ,$$
$$\partial_z \Phi = ZeA_z(t, z) \ . \tag{6.6.8}$$

are mutually consistent only if the electric field in the axial direction vanishes. They are not however consistent with the right hand side of the equation and only one of the conditions can be

satisfied. The condition effectively reduces the equation to an ordinary differential equation. Of course, one cannot assume the condition for general solutions.

For a constant potential difference V_0 the Josephson current is sinusoidal for $\partial_t \Phi = ZeV_0$ ansatz with the basic frequency given by $\omega = eV_0$. An exact treatment replaces the sinusoidal time dependence of Φ with the time dependence of the angle coordinate of gravitational pendulum so that higher harmonics are involved. In the case of cell membrane $V(t)$ is typically a sum of constant part and time dependent part giving rise to frequency modulation of the basic Josephson current:

$$\omega(t) = eV = eV_0 + eV_1(t) \ .$$

Entire hierarchy of frequency modulations is possible since also eV_1 can be frequency modulated by Josephson currents.

6.6.2 Simplest Solutions Of Sine-Gordon Equation

Free Sine-Gordon equation resulting, when the coupling to the em field can be neglected, gives a good view about the solutions of full equation. In cylindrical geometry Sine-Gordon equation becomes effectively 2-dimensional under rather natural conditions. This is rather nice since two-dimensional Sine-Gordon equation is completely integrable and thus allows an infinite number of conserved charges [B6].

Sine-Gordon equation allows two kinds of vacua. The vacua of first type correspond to $\Phi = 2n\pi$ ground state configuration and vacua second type to $\Phi = (2n+1)\pi$. The small perturbations around these vacua correspond to massive 1+2 dimensional free field theory with field equations

$$
\begin{aligned}
D\Phi &= \epsilon \frac{1}{\Lambda^2} \Phi \ ; \\
D &= \partial_t^2 - \nabla^2 \ , \\
\epsilon &= -1 \ \text{for} \ \Phi = n2\pi \ , \\
\epsilon &= 1 \ \text{for} \ \Phi = (2n+1)\pi \ .
\end{aligned}
\tag{6.6.9}
$$

In the language of quantum field theory, the small perturbations around $\Phi = n2\pi$ describe particle with mass squared $m^2 = \frac{1}{\Lambda^2}$ whereas the small perturbations of the $\Phi = (2n+1)\pi$ vacuum describe tachyons with negative mass squared $m^2 = -\frac{1}{\Lambda^2}$. Therefore these vacua will be referred to as time like and space-like respectively.

One might argue that the space-like vacua are un-stable in the case that the continuous sheet of the Josephson junctions consists actually of discrete Josephson junctions, whose dynamics is given by the differential equation

$$\frac{d^2\Phi}{dt^2} = -\frac{sin(\Phi)}{\Lambda^2}$$

allowing only $\Phi = n2\pi$ as stable ground state. For MEs acting as Josephson junction the situation is different. On the other hand, the ground state at which soliton generation is possible should be quantum critical and hence very sensitive to external perturbations. Note that time like and space-like sectors in axonal portion of neuron are permuted by a duality transformation $z \leftrightarrow vt$ (v=c=1), $\Phi \rightarrow \Phi + \pi$, which is exact symmetry of the 1+1-dimensional Sine-Gordon equation.

The propagating waves are of form $sin(u)$, where one has

$$
\begin{aligned}
u &= \gamma_P(t - \frac{v_P z}{v^2}) \ , \quad \text{time like case} \\
u &= \gamma_P(z - v_P t) \ , \quad \text{space-like case} \\
\gamma_P &= \sqrt{\frac{1}{1 - (\frac{v_P}{v})^2}} \ .
\end{aligned}
\tag{6.6.10}
$$

Here v_P is the velocity parameter characterizing the boost. The frequency of these small propagating oscillations (plane waves) is in two cases given by

$$\Omega \;=\; \frac{\gamma_P v}{\Lambda} \;,\;\; \text{time like case} \;,$$

$$\Omega \;=\; \frac{\gamma_P v_P}{\Lambda} \;,\;\; \text{space-like case} \;. \tag{6.6.11}$$

The frequency is very high for time like waves, of order 10^{10} Hz and therefore a typical time scale for the conformational dynamics of proteins. In space-like case the phase velocity of the propagating waves is $v_P < v$ and frequencies are small and one could consider the possibility of identifying these oscillations as propagating EEG waves. For the time like excitations phase velocity is $v_p = v^2/v_P > v$ and larger than light velocity. For ordinary elementary particles the situation is same but since phase velocity is in question, there are no interpretational problems.

One-dimensional solutions of the Sine-Gordon equation give quite satisfactory picture about the situation as far as the physical interpretation is considered. The simplest solutions of this type correspond to solutions depending on time or spatial coordinates only. For time like vacua one-dimensional solutions depend on time only: note that these solutions are possible for arbitrary geometry of the Josephson junction. For space-like like vacua one-dimensional solutions are possible in the axonal portions of the neuron: the simplest one-dimensional solutions depend on the axonal coordinate z only.

Field equations reduce to the equations of motion for gravitational pendulum:

$$\frac{d^2\Phi}{du^2} \;=\; -\frac{1}{\Lambda^2} sin(\Phi) \;. \tag{6.6.12}$$

$u = vt$ holds true in time like case ($v = c \equiv 1$ is good approximation). $u = z$ holds true in space-like case (in this case equation makes sense for axonal portions only). Energy conservation for the gravitational pendulum gives

$$\frac{1}{2}v^2(\frac{d\Phi}{du})^2 + \frac{v^2}{\Lambda^2}\left[1 - cos(\Phi)\right] \;=\; K\frac{2v^2}{\Lambda^2} \;, \tag{6.6.13}$$

where K is dimensionless constant analogous to energy. There are two kinds of solutions: oscillating solutions ($K < 1$) and rotating solutions ($K > 1$): single soliton solution corresponds to $K = 1$.

One can integrate the conservation law for energy to give the time/spatial period of oscillation or rotation (T/λ). For oscillating solutions one has

$$T \;=\; \frac{\lambda}{v} = \frac{\Lambda}{v} \int_{-\Phi_0}^{+\Phi_0} d\Phi \frac{1}{\sqrt{2\left[-cos(\Phi_0) + cos(\Phi)\right]}} \;. \tag{6.6.14}$$

Here Φ_0 is maximum value of the phase angle for oscillating solution. For the rotation period one obtains

$$T \;=\; \frac{\lambda}{v} = \frac{\Lambda}{v} \int_{0}^{2\pi} d\Phi \frac{1}{\sqrt{(\frac{d\Phi}{dt})^2(\Phi = \pi) + 2\left[1 - cos(\Phi)\right]}} \;. \tag{6.6.15}$$

By Lorentz-boosting space-like axonal solutions to move with velocity v_p one obtains propagating soliton sequences.

Sine-Gordon equation is completely integrable and thus allows an infinite number of conserved charges. In quantum theory the eigenvalues of mutually commuting charges characterize the quantum state and these charges are basic quantum observables. Does it make sense to quantize Sine-Gordon and could one characterize the state of the axonal membrane in terms of these charges? Here one must point out the similarity to the ideas of Nanopoulos [J32], who speculates with the possibility that certain 2-dimensional conformal field theory characterizes the state of micro-tubule and the infinite number of conserve charges characterize the information content of the micro-tubule. It is perhaps also worth of mentioning that the quantum group $SU(2)$ appears in the quantization of the Sine-Gordon equation [B20]: could quantum groups have important applications in biology?

6.6.3   Are Both Time Like And Space-Like Soliton Sequences Possible Ground States?

The model for the Josephson junction predicts the existence of both time like and space-like soliton sequences. Mathematician would expect that both ground states of coupled super conductors are realized in brain. The presence of space-like and time like modes could provide general insights to brain functioning and could relate to the fundamental dichotomies of brain consciousness.

Time like soliton sequences do not in general propagate and if they propagate, the phase velocity exceeds light velocity (due to $t - vx/c^2$ dependence). The size of coherence region in the case of gap junction connected neurons can be rather large. Also micro-tubuli could form large coherent regions.

The time scales involved with the time like soliton sequence are however very fast, much faster that the time scales of EEG. This suggests that soliton sequences and oscillations are responsible for a synchronization in various scales defined by p-adic and dark matter hierarchies. One cannot exclude the possibility that the appearance of time like soliton sequences correlates with the emergence of standing EEG waves and synchronous firing whereas propagating space-like soliton sequences could accompany nerve pulse conduction. Since non-propagating collective firing does not occur, standing soliton sequences could be associated with glial cells and propagating soliton sequences with neuronal axons.

Soliton sequences could provide a general realization of biological clocks and facilitate the generation of macroscopic quantum systems. Also the gap junction connected neuron groups associated with primary sensory organs, various organs and brain could correspond to time like solitons.

For ordinary value of $\hbar$ the small oscillations for time like ground state have period of order 10^{-10} seconds: this follows solely from the spatial extension of nerve pulse of order $\Lambda \sim 10^{-2}$ meters and involves no assumptions about the detailed properties of the super conductor. These oscillations could coordinate protein dynamics. I do not know whether endoplasma membranes inside cells have resting potential: if not, they are good candidates for the carriers of time like ground states with oscillating voltage.

For cell membrane situation is different and the only possible interpretation is that the resting potential for ordinary value of Planck constant and for far-from-vacuum ground state corresponds to the 10^{-13} second time scale determined by the membrane voltage and the mechanical analog is very rapidly rotating gravitational pendulum. Almost vacuum extremal property and large values of Planck constant change the situation and $k_d = 47$ level would correspond to 5 Hz oscillation frequency. Note that the hypothesis is $h_{eff} = nh$, where n is product of distinct Fermat primes and power 2^{k_d}. These time-like soliton sequences could indeed be interpreted as standing EEG waves whereas space-like soliton sequences would correspond to propagating EEG waves. The presence of perturbations appearing at multiples of cyclotron frequencies of biologically important ions means that standing and moving waves at other frequencies are possible. Nerve pulse patterns induces frequency modulations of the corresponding Josephson currents and Josephson radiation.

Glial cells [I47] form a considerable fraction of cell population of brain are glial cells and are connected to each other by gap junctions, which can serve as Josephson junctions. In glial cells large amplitude oscillations with longer oscillation period could be present. The ciliar beating of monocellular animals [I47] could be coordinated to coherent motion (making possible swimming of the monocellular organism) by the "EEG" waves.

Gap junctions between the nerve cells are not common but are encountered in the large coherently firing groups of nerve cells in the brain, in the sensory organs and other organs such as heart. The value of the parameter K is only slightly larger than the critical value $K = 1$ for EEG since the period of EEG oscillations is typically by a factor of order 10^8 longer than the period of small oscillations. The problem disappears when higher levels of dark matter hierarchy are allowed. Of course, if the potential difference in question corresponds to the membrane potential, one must have $K \gg 1$. One can wonder whether the criticality might have some deeper significance: perhaps phase transitions between EEG: s corresponding to rotating and oscillating gravitational penduli are possible.

6.6.4 Quantum Tools For Bio-Control And -Coordination

Coordination and control are the two fundamental aspects in the functioning of the living matter. TGD suggests that at quantum level deterministic unitary time evolution of Dirac equation corresponds to coordination whereas time evolution by quantum jumps corresponds to quantum control. More precisely, the non-dissipative Josephson currents associated with weakly coupled super conductors would be the key element in coordination whereas resonant dissipative currents between weakly coupled super conductors would make possible quantum control.

This view allows to consider more detailed mechanisms. What is certainly needed in the coordination of the grown up organism are biological clocks, which are oscillators coupled to the biological activity of the organ. Good examples are the clocks coordinating the brain activity, respiration and heart beat [I120]. For example, in the heart beat the muscle contractions in various parts of heart occur in synchronized manner with a well defined phase differences. Various functional disorders, say heart fibrillation, result from the loss of this spatial coherence. For a control also biological alarm clocks are needed. An alarm clock is needed to tell when the time is ripe for the cell to replicate during morphogenesis. Some signal must tell that is time to begin differentiation to substructures during morphogenesis: for example, in the case of the vertebrates the generation of somites is a very regular process starting at certain phase of development and proceeding with a clockwise precision.

Homeostasis as many-sheeted ionic flow equilibrium

The experimental work of Ling, Sachs and Qin [I96, I137] and other pioneers [I62, I44] challenges the notions of ionic channels and pumps central to the standard cell biology. Ling has demonstrated that the ionic concentrations of a metabolically deprived cell are not changed at all: this challenges the notion of cell membrane ionic pumps. The work of Sachs and Qin and others based on patch-clamp technique shows that the quantal ionic currents through cell membrane remain essentially as such when the membrane is replaced by a silicon rubber membrane or by a cell membrane purified from channel proteins! this challenges the notion of cell membrane ionic channels. A further puzzling observation is much more mundane: ordinary hamburger contains roughly 80 per cent of water and is thus like a wet sponge: why it is so difficult to get the water out of it?

These puzzling observations can be understood if the homeostasis of cell and its exterior is regarded as an ionic flow equilibrium in the many-sheeted space-time. Ionic super currents from super-conducting controlling space-time sheets flow to controlled atomic space-time sheets and back. Currents are of course ohmic at the atomic space-time sheets. One can understand how extremely small ionic densities and super currents at cellular space-time sheets can control ionic currents and much higher ionic densities at atomic space-time sheets. Immense savings in metabolic energy are achieved if the ohmic currents at the atomic space-time sheets flow through the cell membrane region containing the strong electric field along super-conducting cell membrane space-time sheet (rather than atomic space-time sheets) as a non-dissipative supra current. This clever energy saving trick makes also the notion of ionic channels obsolete for weak ionic currents at least.

Super-conducting space-time sheets contain a plan of the bio-system coded to ion densities and magnetic quantum numbers characterizing the super currents. Bio-control by em fields affects these super currents and one can understand the effects of ELF em fields on bio-system in this framework. The model relies crucially on the liquid crystal property of bio-matter (hamburger mystery!) making possible ohmic current circuitry at the atomic space-time sheets as a part of the many-sheeted control circuitry. There is a considerable evidence for this current circuitry, Becker is one of the pioneers in the field [J24]: among other things the circuitry could explain how acupuncture works.

Quantum model for pattern recognition

Time translation invariant pattern recognition circuit can be realized by using two coupled super-conductors. The first super-conductor contains the reference supra current and second super-conductor contains the supra current determined by the sensory input. Supra currents are assumed to have same spatially and temporally constant intensity. If the supra currents have spatially constant phase difference, also Josephson currents are in the same phase and sum up to a large current

facilitating synchronous firing. The temporal phase difference of supra currents does not matter since it affects only the overall phase of the Josephson current. Therefore patterns differing by time translations are treated as equivalent. Quite generally, the requirement of time translational invariance, favors the coding of the sensory qualia to transition frequencies.

The destructive interference of supra currents provides an tool of pattern cognition in situations when the precise timing is important. The pattern to be recognized can be represented as a reference current pattern in some neuronal circuit. Input pattern determined by sensory input in turn is represented by supra current interfering with the reference current. If interference is destructive, synchronous generation of nerve pulses in the circuit occurs and leads to a conscious pattern recognition. Obviously the loss of time translation invariance makes this mechanism undesirable in the situations in which the precise timing of the sensory input does not matter. One can however imagine situations when timing is important: for instance, the deduction of the direction of the object of the auditory field from the phase difference associated with signals entering into right and left ears could correspond to this kind of situation.

In both cases one can worry about the regeneration of reference currents. The paradigm of four-dimensional quantum brain suggests that sensory input leads by self-organization to a stationary spatial patterns of supra-currents and this process depends only very mildly on initial values. Thus self-organization would generate automatically pattern recognizers.

General mechanism making possible biological clocks and alarm clocks, comparison circuits and novelty detectors

Weakly coupled super conductors and quantum self-organization make possible very general models of biological clocks and alarm clocks as well as comparison circuits and novelty detectors.

The Josephson junction between two super-conductors provides a way to realize a biological clock. Josephson current can be written in the form [D71]

$$
\begin{aligned}
J &= J_0 sin(\Delta\Phi) = J_0 sin(\Omega t) \ , \\
\Omega &= ZeV \ ,
\end{aligned}
\tag{6.6.16}
$$

where Ω is proportional to the potential difference over the Josephson junction. Josephson current flows without dissipation.

In BCS theory of super-conductivity the value of the current J_0 can be expressed in terms of the energy gap Δ of the super conductor and the ordinary conductivity of the junction. When the temperature is much smaller than critical temperature, the current density for a junction is given by the expression [D71]

$$
J_0 = \frac{\pi}{2e}\frac{\sigma_s\Delta}{d} \ .
\tag{6.6.17}
$$

Here σ_s is the conductivity of the junction in the normal state assuming that all conduction electrons can become carriers of the supra current. d is the distance between the super conductors. The current in turn implies a position independent(!) oscillation of the Cooper pair density inside the two super conductors. By the previous arguments the density of the Cooper pairs is an ideal tool of bio-control and a rhythmic change in biological activity expected to result in general. Josephson junctions are therefore good candidates for pacemakers not only in brain but also in heart and in respiratory system.

In the presence of several parallel Josephson junctions quantum interference effects become possible if supra currents flow in the super conductors. Supra current is proportional to the gradient of the phase angle associated with the order parameter, so that the phase angle Φ is not same for the Josephson junctions anymore and the total Josephson current reads as

$$
J = \sum_n J_0(n)sin(\Omega t + \Delta\Phi(n)) \ .
\tag{6.6.18}
$$

It is clear that destructive interference takes place. The degree of the destructive interference depends on the magnitude of the supra currents and on the number of Josephson junctions.

There are several options depending on whether both super conductors carry parallel supra currents or whether only second super conductor carries supra current.

1. If both super conductors carry supra currents of same magnitude but different velocity, the phases associated with the currents have different spatial dependence and destructive interference occurs unless the currents propagate with similar velocity. This mechanism makes possible comparison circuit serving as a feature detector. What is needed is to represent the feature to be detected by a fixed supra current in the second super conductor and the input as supra current with same charge density but difference velocity. The problem is how the system is able to generate and preserve the reference current. If case that feature detector "wakes-up" into self state when feature detection occurs, the subsequent quantum self-organization should lead to the generation of the reference current representing the feature to be detected.

2. If only second super conductor carries supra current and of this supra current for some reason decreases or becomes zero, constructive interference occurs for individual Josephson currents and net Josephson current increases: current causes large gradients of Cooper pair density and can lead to the un-stability of the structure. When the supra current in the circuit dissipates below a critical value, un-stability emerges. This provides a general mechanism of biological alarm clock.

   Assume that the second super conductor carriers a supra current. As the time passes the reference current dissipates by phase slippages [D67, D71]. If the reference current is large enough, the dissipation takes place with a constant rate. This in turn means that the Josephson current increases in the course of time. When the amplitude of the Josephson current becomes large enough, the density gradients of the charge carriers implied by it lead to a un-stability of the controlled system: the clock rings. Since the dissipation of (a sufficiently large) Josephson current takes place at constant rate this alarm clock can be quite accurate. It will be found that a variant of this mechanism might be at work even in the replication of DNA. The un-stability itself can regenerate the reference current to the clock. If the alarm clock actually "wakes-up" the alarm clock to self state, self-organization by quantum jumps must lead to an asymptotic self-organization pattern in which the supra current in the circuit is the original one. Actually this should occur since asymptotic self-organization pattern depends only weakly on the initial values.

3. Novelty detector can be build by feeding the outputs of the feature detectors to an alarm clock circuit. In alarm clock circuit only the second super conductor carries supra current, which represents the sum of the outputs of the feature detectors. Since the output of a feature detector is non-vanishing only provided the input corresponds to the feature to be detected, the Josephson current in additional circuit becomes large only when the input does not correspond to any familiar pattern.

How MEs could generate soliton sequences?

MEs could as bio-controllers using the same general mechanism which underlies remote mental interactions and this aspect of bio-control could be seen as endogenous remote mental interactions between cells and other parts of organism. Pairs of low and high frequency MEs are involved. Low frequency MEs, say EEG MEs, serve as correlates for quantum entanglement between body parts: already this is enough for remote viewing regarded as sharing of mental images by fusion of mental images. The psychokinesis aspect is possible by high frequency MEs propagating like massless particles inside low frequency MEs. These MEs induce bridges and thus leakage of ions between various space-time sheets at the receiving end. This means self-organization by dissipation.

MEs can also act as Josephson junctions connecting super-conducting space-time sheet characterized by p-adic primes which can be different. This kind of Josephson junction contains the em field associated with ME as an external field and the mathematical description of this coupling follows from the model for the coupling of electromagnetic field to super conducting order parameters. In Minkowski coordinates the modification of the Sine-Gordon equation is simple:

$$\partial^\mu \left[\partial_\mu \Phi - Ze\Delta A_\mu \right] \;\; = \;\; m_{12}^2 sin(\Phi) \;\; . \tag{6.6.19}$$

Here Φ denotes the phase difference over the Josephson junction, which is idealized with a continuous Josephson junction, and actually is a continuous Josephson junction in the case of ME. ΔA_μ denotes the difference of the vector potential over the junction.

The coupling to the vector potential can in the lowest order described by the condition

$$\partial_\mu \Phi_0 = Ze\Delta A_\mu$$

assumed to hold for a maximal number of components of vector potential. Here of course integrability conditions pose restrictions. One can develop perturbation series for Φ by substituting Φ_0 to the right hand side and calculating Φ_1 using the right hand side as a source term, and so on.

If the transversal em field associated with ME contains time independent radial electric field this gives rise to a constant potential term giving rise to a generation of soliton sequences. The period Ω of rotation for the soliton satisfies $\Omega = eV$, where eV corresponds to the potential difference defined by the constant part of the electric field of ME. It can also happen that ME contains only the oscillatory electromagnetic field: if the frequency is same as the frequency associated with small oscillations of the Sine-Gordon pendulum a resonant coupling is expected to result. In this case the frequency is in radio frequency range.

Also noise is present and it is quite possible that the noise provides the energy needed to amplify the weak periodic signal provided by ME to a soliton sequence by stochastic resonance. The mechanism is discussed in detail in the chapter "Quantum model for EEG and nerve pulse". This suggests that MEs could basically control small very fast oscillations of the membrane potential.

6.7 Model For The Hierarchy Of Josephson Junctions

As far as hierarchy of EEGs and its generalizations is considered the hierarchy of Josephson junctions assignable to cell membrane itself is relevant. Dark matter hierarchy and p-adic fractality allow to imagine a fractal hierarchy of structures analogous to cell membrane with arbitrarily large thickness. One can even imagine scaled up variants of cell membrane with different p-adic length scale and value of Planck constant but possessing same membrane potential as ordinary cell membrane. The generalization of the embedding space helps to understand what is involved and is discussed in Appendix.

6.7.1 The Most Recent Model For The Generation Of Nerve Pulse

For some time ago I learned [J13, J16, J83, J84, J95] (thanks to Ulla Mattfolk) that nerve pulse propagation seems to be an adiabatic process and thus does not dissipate: the authors propose that 2-D acoustic soliton is in question. Adiabaticity is what one expects if the ionic currents are dark currents (large $\hbar$ and low dissipation) or even supra currents. Furthermore, Josephson currents are oscillatory so that no pumping is needed. Combining this input with the model of DNA as topological quantum computer (TQC) [K5] leads to a rather precise model for the generation of nerve pulse.

1. The system would consist of two superconductors- microtubule space-time sheet and the space-time sheet in cell exterior- connected by Josephson junctions represented by magnetic flux tubes defining also braiding in the model of TQC. The phase difference between two super-conductors would obey Sine-Gordon equation allowing both standing and propagating soliton solutions. A sequence of rotating gravitational penduli coupled to each other would be the mechanical analog for the system. Soliton sequences having as a mechanical analog penduli rotating with constant velocity but with a constant phase difference between them would generate moving kHz synchronous oscillation. Periodic boundary conditions at the ends of the axon rather than chemistry determine the propagation velocities of kHz waves and kHz synchrony is an automatic consequence since the times taken by the pulses to travel along the axon are multiples of same time unit. Also moving oscillations in EEG range can be considered and would require larger value of Planck constant in accordance with vision about evolution as gradual increase of Planck constant.

2. During nerve pulse one pendulum would be kicked so that it would start to oscillate instead of rotating and this oscillation pattern would move with the velocity of kHz soliton sequence.

The velocity of kHz wave and nerve pulse is fixed by periodic boundary conditions at the ends of the axon implying that the time spent by the nerve pulse in traveling along axon is always a multiple of the same unit: this implies kHz synchrony. The model predicts the value of Planck constant for the magnetic flux tubes associated with Josephson junctions and the predicted force caused by the ionic Josephson currents is of correct order of magnitude for reasonable values of the densities of ions. The model predicts kHz em radiation as Josephson radiation generated by moving soliton sequences. EEG would also correspond to Josephson radiation: it could be generated either by moving or standing soliton sequences (latter are naturally assignable to neuronal cell bodies for which $\hbar$ should be correspondingly larger): synchrony is predicted also now.

3. The previous view about microtubules in nerve pulse conduction can be sharpened. Microtubular electric field (always in the same direction) could explain why kHz and EEG waves and nerve pulse propagate always in same direction and might also feed energy to system so that soliton velocity could be interpreted as drift velocity. This also inspires a generalization of the model of DNA as TQC sine also microtubule-cell membrane systems are good candidates for performers of TQC. Cell replication during which DNA is out of game seems to require this and microtubule-cell membrane TQC would represent higher level TQC distinguishing between multi-cellulars and mono-cellulars.

4. New physics would enter in several ways. Ions should form Bose-Einstein cyclotron condensates. The new nuclear physics predicted by TGD [L3], [L3] predicts that ordinary fermionic ions (such as K^+, Na^+, Cl^-) have bosonic chemical equivalents with slightly differing mass number obtained by replacing one or more neutral color flux tubes connecting nucleons of neutral atom with a charged one. Anomalies of nuclear physics and cold fusion provide experimental support for the predicted new nuclear physics. Electronic supra current pulse from microtubules could induce the kick of pendulum inducing nerve pulse and induce a small heating and expansion of the axon. The return flux of ionic Josephson currents would induce convective cooling of the axonal membrane. A small transfer of small positive charge into the inner lipid layer could induce electronic supra current by attractive Coulomb interaction. The exchange of exotic W bosons which are scaled up variants of ordinary $W^\pm$ bosons is a natural manner to achieve this if new nuclear physics is indeed present.

6.7.2   Quantum model for sensory receptor

This original model of nerve pulse and EEG was still based on the implicit assumption that the space-time sheet carrying the Josephson currents is far from vacuum. The model for sensory receptor and sensory qualia however led to a the proposal that the space-time sheet in question is near vacuum extremal [K50, K91]. Near vacuum extremal property does not affect the general structure of the model in an essential manner.

1. The only change [K91, K92] is the replacement of charges ± 1 of ions with effective charges given as

$$Q_{eff} \quad = \quad -\frac{Z-N}{2p} + 2Z + q_{em} \quad . \tag{6.7.1}$$

   Z and N denote nuclear charge and neutron number. $p = sin^{(}\theta_W)$ corresponds to Weinberg angle. For K^+, Cl^-, Na^+, Ca^{++} one has $Z = (19, 17, 11, 20)$, $Z - N = (-1, -1, -1, 0)$, and $q_{em} = (1, -1, 1, 2)$. **Table 6.4** gives the values of Josephson energies for some values of resting potential for $p = sin^{(}\theta_W) = .0295$ reproducing the frequencies of peak sensitivity for photoreceptors. Rather remarkably, they are in IR or visible range.

2. The energies are in UV and visible range. Hence one can consider also Josephson junctions with considerably lower membrane potentials of order mV are possibly without losing the thermal stability. For instance, one could consider $k = 151, 157, 163, 167$ Josephson junctions with a membrane potential scaling as $1/L(k)$. For $k = 167$ the energies would be scaled down

Ion	Na^+	Cl^-	K^+	Ca^{+2}
$E_J(.04\ mV, p = .23)/eV$	1.01	1.40	1.51	1.76
$E_J(.065\ V, p = .23)/eV$	1.64	2.29	2.69	2.73
$E_J(40\ mV, p = .0295)/eV$	1.60	2.00	2.23	1.68
$E_J(50\ mV, p = .0295)/eV$	2.00	2.49	2.79	2.10
$E_J(55\ mV, p = .0295)/eV$	2.20	2.74	3.07	2.31
$E_J(65\ mV, p = .0295)/eV$	2.60	3.25	3.64	2.73
$E_J(70\ mV, p = .0295)/eV$	2.80	3.50	3.92	2.94
$E_J(75\ mV, p = .0295)/eV$	3.00	3.75	4.20	3.15
$E_J(80\ mV, p = .0295)/eV$	3.20	4.00	4.48	3.36
$E_J(90\ mV, p = .0295)/eV$	3.60	4.50	5.04	3.78
$E_J(95\ mV, p = .0295)/eV$	3.80	4.75	5.32	3.99
Color	R	G	B	W
E_{max}	2.19	2.32	3.06	2.49
energy-interval/eV	1.77-2.48	1.97-2.76	2.48-3.10	

Table 6.4: Table gives the prediction of the model of photoreceptor for the Josephson energies for typical values of the membrane potential. For comparison purposes the energies E_{max} corresponding to peak sensitivities of rods and cones, and absorption ranges for rods are also given. R, G, B, W refers to red, green, blue, white. The values of Weinberg angle parameter $p = sin^2(\theta_W)$ are assumed to be .23 and.0295. The latter value is forced by the fit of Josephson energies to the known peak energies.

by a factor $2^{-(167-151)/2} = 2^{-8}$ giving for $V_{eff} = .09$ V a photon energy somewhat below the thermal energy at room temperature. On the other hand, the fact that Josephson junctions with a vanishing Z^0 field are at the verge of thermal instability suggests that also they might be present in living matter.

3. From **Table 6.4** one can evaluate the value of Planck constant for a given Josephson frequency for various ions. For $f_J = 5$ Hz giving a first estimate for neuronal Josephson frequency and V=-55 mV corresponding to the critical voltage for the generation of action potential one obtains the values $r = \hbar/\hbar_0 = (1.51, 1.89, 2.11, 1.59) \times 2^{46}$ for $(Na^+, Cl^-, K^+, Ca^{++})$. For V=-70 mV corresponding to the resting potential of neuron and same Josephson frequency one obtains $r = (0.961.201.341.01) \times 2^{47}$. For Ca^{++} ion r is very near to a power of 2. A good mnemonic is that the Josephson energies of biologically important ions vary in an interval, which is in a reasonable approximation half octave $(E_J(K^+)/E_J(Na^+) = 1.3958 \simeq \sqrt{2} \simeq 1.4142)$.

It interesting to try to interpret the resting potentials of various cells in this framework in terms of the Josephson frequencies of various ions. **Table 6.4** gives the values of Josephson frequencies of basic biological ions for typical values of the membrane potential.

1. The maximum value of the action potential during nerve pulse is +40 mV so that Josephson frequencies are same as for the resting state of photoreceptor. Note that the time scale for nerve pulse is so slow as compared to the frequency of visible photons that one can consider that the neuronal membrane is in a state analogous to that of a photoreceptor.

2. For neurons the value of the resting potential is -70 mV. Na^+ and Ca^{++} Josephson energies 2.80 eV and 2.94 eV are in the visible range in this case and correspond to blue light. This does not mean that Ca^{++} Josephson currents are present and generate sensation of blue at neuronal level: the quale possibly generated should depend on sensory pathway. During the hyper-polarization period with -75 mV the situation is not considerably different.

3. The value of the resting potential is -95 mV for skeletal muscle cells. In this case Ca^{++} Josephson frequency corresponds to 4 eV metabolic energy quantum.

4. For smooth muscle cells the value of resting potential is -50 mV. In this case Na^+ Josephson frequency corresponds to 2 eV metabolic energy quantum.

5. For astroglia the value of the resting potential is -80/-90 mV for astroglia. For -80 mV the resting potential for Cl^- corresponds to 4 eV metabolic energy quantum. This suggests that glial cells could also provide metabolic energy as Josephson radiation to neurons.

6. For all other neurons except photo-receptors and red blood cells Josephson photons are in visible and UV range and the natural interpretation would be as bio-photons. The bio-photons detected outside body could represent sensory leakage. An interesting question is whether the IR Josephson frequencies could make possible some kind of IR vision.

6.7.3   The Role Of Josephson Currents

The general vision is that Josephson currents of various ions generate Josephson photons having dual interpretations as bio-photons and EEG photons. Josephson photons can in principle regenerate the quale in the neurons of the sensory pathway. In the case of motor pathways the function would be different and the transfer of metabolic energy by quantum credit card mechanism using phase conjugate photons is suggested by the observation that basic metabolic quanta 2 eV *resp.* 4 eV are associated with smooth muscle cells *resp.* skeletal muscle cells.

   As already found in the previous section, the energies of Josephson photons associated with the biologically important ions are in general in visible or UV range except when resting potential has the value of -40 mV which it has for photoreceptors. In this case also IR photons are present. Also the turning point value of membrane potential is +40 mV so that one expects the emission of IR photons.

   Josephson photons could be used to communicate the qualia to the magnetic body.

1. If Josephson currents are present during the entire action potential, the entire range of Josephson photons down to frequencies of order 2 kHz range is emitted for the standard value of $\hbar$. The reason is that lower frequencies corresponds to cycles longer than the duration of the action potential. The continuum of Josephson frequencies during nerve pulse makes it possible to induce cyclotron transitions at the magnetic body of neuron or large structure. This would make possible to communicate information about spatial and temporal behavior of the nerve pulse pattern to the magnetic body and build by quantum entanglement a sensory map.

2. The frequencies below 2 kHz could be communicated as nerve pulse patterns. When the pulse rate is above $f = 28.57$ Hz the sequence of pulses is experienced as a continuous sound with pitch f. f defines the minimum frequency for which nerve pulses could represent the pitch and there remains a 9 Hz long range to be covered by some other communication method.

3. The cyclotron frequencies of quarks and possibly also of electron would make possible a selective reception of the frequencies emitted during nerve pulse. Same applies also to the Josephson frequencies of hair cell (, which does not fire). If the value of Planck constant is large this makes possible to communicate the entire range of audible frequencies to the magnetic body. Frequency would be coded by the magnetic field strength of the flux tube. Two options are available corresponding to the standard ground state for which Z^0 field is very weak and to almost vacuum extremals. For the first option one as ordinary cyclotron frequencies. The cyclotron frequency scales for them differ by a factor

$$r(q) = \frac{Q_{eff}(q)}{Q_{em}(q)} = \frac{\epsilon(q)}{2pQ_{em}(q)} + 1 \quad , \quad \epsilon(u) = -1 \ , \epsilon(d) = 1 \tag{6.7.2}$$

from the standard one. For $p = .0295$ one obtains $(r(u), r(d), r(e) = (24.42, 49.85, 15.95)$. The cyclotron frequencies for quarks and electron with masses m(u)=2 MeV, m(d)=5 MeV, and m(e)=.5 MeV are given by **Table 6.5** for the two options. If one assumes that B_{end} defines the upper bound for field strength then he standard option would require both d

fermion	$f_c(e)/MHz$	$f_c(u)/MHz$	$f_c(d)/MHz$
standard	.564	.094	.019
nearly vacuum extremal	8.996	2.275	.947

Table 6.5: Cyclotron frequencies of quarks and electron in magnetic field $B_{end} = .2$ Gauss for standard vacuum with very small Z^0 field and nearly vacuum extremal.

quark and electron. Gor $d$quark with kHz CD the upper bound for cyclotron frequencies would be 20 kHz which corresponds to the upper limit of audible frequencies.

4. Besides cyclotron frequencies also the harmonics of the fundamental frequencies assignable to quark and electron CDs could be used and in case of musical sounds this looks a highly attractive option. In this case it is now however possible to select single harmonics as in the case of cyclotron transitions so that only the rate of nerve pulses can communicate single frequency. Lorentz transform sub-CD scales up the frequency scale from the secondary p-adic time scale coming as octave of 10 Hz frequency. Also the scaling of $\hbar$ scales this frequency scale.

6.7.4 What Is The Role Of The Magnetic Body?

The basic vision is that magnetic body receives sensory data from the biological body- basically from cell membranes and possibly via genome - and controls biological body via genome. This leaves a huge amount of details open and the almost impossible challenge of theoretician is to guess the correct realization practically without any experimental input. The following considerations try to clarify what is involved.

Is magnetic body really needed?

Libet's findings and the model of memory based on time mirror (see **Fig. `http://tgdtheory.fi/appfigures/timemirror.jpg`** or **Fig. ??** in the appendix of this book) hypothesis suggests that magnetic body is indeed needed. What is the real function of magnetic body? Is it just a sensory canvas? The previous considerations suggest that it is also the seat of geometric qualia, in particular the pitch of sound should be coded by it. It would be relatively easy to understand magnetic body as a relatively passive sensory perceiver defining sensory map. If one assumes that motor action is like time reversed sensory perception then sensory and motor pathways would be just sensory pathways proceeding in opposite time directions from receptors to the various layers of the magnetic body. Brain would perform the information processing.

Certainly there must exist a region in which the motor and sensory parts of the magnetic body interact. What comes in mind is that these space-time sheets (or actually pairs of space-time sheets) are parallel and generate wormhole contacts between them. This interaction would be assignable to the region of the magnetic body could receive positive energy signals from associative sensory areas and send negative energy signals to motor motor neurons at the ends of motor pathways wherefrom they would propagate to premotor cortex, supplementary motor cortex and to frontal lobes where the abstract plans about motor actions are generated.

Is motor action time reversal of sensory perception in zero energy ontology?

One could argue that the free will aspect of motor actions does not conform with the interpretation as sensory perception in reversed direction of time. On the other hand, also percepts are selected -say in binocular rivalry [J45]. Only single alternative percept need to be realized in a given branch of the multiverse. This makes possible metabolic economy: for instance, the synchronous firing at kHz frequency serving as a correlate for the conscious percept requires a lot of energy since dark photons at kHz frequency have energies above thermal threshold. Similar selection of percepts could occur also at the level of sensory receptors but quantum statistical determinism would guarantee reliable perception. The passivity of sensory perception and activity of motor activity would reflect the breaking of the arrow of time if this interpretation is correct.

What magnetic body looks like?

What magnetic body looks like has been a question that I have intentionally avoided as a question making sense only when more general questions have been answered. This question seems however unavoidable now. Some of the related questions are following. The magnetic flux lines along various parts of magnetic body must close: how does this happen? Magnetic body must have parts of size at least that defined by EEG wavelengths: how do these parts form closed structures? How the magnetic bodies assignable to biomolecules relate to the Earth sized parts of the magnetic body? How the personal magnetic body relates to the magnetic body of Earth?

1. The vision about genome as the brain of cell would suggest that active and passive DNA strands are analogous to motor and sensor areas of brain. This would suggests that sensory data should be communicated from the cell membrane along the passive DNA strand. The simplest hypotesis is that there is a pair of flux sheet going through the DNA strands. The flux sheet through the passive strand would be specialized to communicate sensory information to the magnetic body and the flux sheet through the active strand would generate motor action as DNA expression with transcription of RNA defining only one particular aspect of gene expression. Topological quantum computation assignable to introns and also electromagnetic gene expression would be possible.

2. The model for sensory receptor in terms of Josephson radiation suggests however that flux tubes assignable to axonal membranes carry Josephson radiation. Maybe the flux tube structures assigned to DNA define the magnetic analog of motor areas and flux tubes assigned with the axons that of sensory areas.

3. A complex structure of flux tubes and sheets is suggestive at the cellular level. The flux tubes assignable to the axons would be parallel to the sensory and motor pathways. Also microtubules would be accompanied by magnetic flux tubes. DNA as topological quantum computer model assumes and the proposed model of sensory perception and cell membrane level suggests transversal flux tubes between lipids and nucleotides. The general vision about DNA as brain of cell suggest flux sheets through DNA strands.

   During sensory perception of cell and nerve pulse the wormhole flux tube connecting the passive DNA strand of the first cell to the inner lipid layer would recombine with the flux tube connecting outer lipid layer to some other cell to form single flux tube connecting two cells. In the case of sensory organs these other cells would be naturally other sensory receptors. This would give rise to a dynamical network of flux tubes and sheets and axonal sequences of genomes would be like lines of text at the page of book. This structure could have a fractal generalization and would give rise to an integration of genome to super-genome at the level of organelles, organs and organism and even hypergenome at the level of population. This would make possible a coherent gene expression.

4. This vision gives some idea about magnetic body in the scale of cell but does not say much about it in longer scales. The CDs of electrons and quarks could provide insights about the size scale for the most relevant parts of the magnetic body. Certainly the flux tubes should close even when they have the length scale defined by the size of Earth.

   Additional ideas about the structure follow follow if one assumes that magnetic body acts a sensory canvas and that motor action can be regarded as time reversed sensory perception.

1. If the external world is represented at part of the magnetic body which is stationary, the rotation of head or body would not affect the sensory representation. This part of the magnetic body would be obviously analogous to the outer magnetosphere, which does not rotate with Earth.

2. The part of the magnetic body at which the sensory data about body (posture, head orientations and position, positions of body parts) is represented, should be fixed to body and change its orientation with it so that bodily motions would be represented as motions of the magnetic , which would be therefore analogous to the inner magnetosphere of rotating Earth.

3. The outer part of the personal magnetic body is fixed to the inner magnetosphere, which defines the reference frame. The outer part might be even identifiable as the inner magneto-sphere receiving sensory input from the biosphere. This magnetic super-organism would have various life forms as its sensory receptors and muscle neurons. This would give quantitative ideas about cyclotron frequencies involved. The wavelengths assignable to the frequencies above 10 Hz would correspond to the size scale of the inner magnetosphere and those below to the outer magnetosphere. During sleep only the EEG communications with outer magnetic body would remain intact.

4. Flux quantization for large value of $\hbar$ poses an additional constraint on the model.

   (a) If Josephson photons are transformed to a bunch of ordinary small $\hbar$ photons magnetic flux tubes can correspond to the ordinary value of Planck constant. If one assumes the quantization of the magnetic flux in the form

   $$\int BdA = n\hbar$$

   used in super-conductivity, the radius of the flux tube must increase as $\sqrt{\hbar}$ and if the Josephson frequency is reduced to the sound frequency, the value of $\hbar$ codes for the sound frequency. This leads to problems since the transversal thickness of flux tubes becomes too large. This does not however mean that the condition might not make sense: for instance, in the case of flux sheets going through DNA strands the condition might apply.

   (b) The quantization of magnetic flux could be replaced by a more general condition

   $$\oint (p - ZeA)dl = n\hbar \ , \tag{6.7.3}$$

   where p represents momentum of particle of super-conducting phase at the boundary of flux tube. In this case also $n = 0$ is possible and poses no conditions on the thickness of the flux tube as a function of $\hbar$. This option looks reasonable since the charged particles at the boundary of flux tube would act as sources of the magnetic field.

   (c) Together with the Maxwell's equation giving $B = ZeNv$ in the case that there is only one kind of charge carrier this gives the expression

   $$N \quad = \quad \frac{2m}{RZ^2e^2} \tag{6.7.4}$$

   for the surface density N of charge carrier with charge Z. R denotes the radius of the flux tube. If several charge carriers are present one has $B = \sum_k N_k Z_k ev_k$, and the condition generalizes to

   $$N_i \quad = \quad \frac{2m_iv_i}{RZ_i \sum_k Z_k v_k e^2} \ . \tag{6.7.5}$$

   It seems that this condition is the most realistic one for the large $\hbar$ flux sheets at which Josephson radiation induces cyclotron transitions.

What are the roles of Josephson and cyclotron photons?

The dual interpretation of Josephson radiation in terms of bio-photons and EEG photons seems to be very natural and also the role of Josephson radiation seems now relatively clear. The role of cyclotron radiation and its interaction with Josephson radiation are not so well understood.

1. At least cell membrane defines a Josephson junction (actually a collection of them idealizable as single junctions). DNA double strand could define a series of Josephson junctions possibly assignable with hydrogen bonds. This however requires that the strands carry some non-standard charge densities and currents- I do not know whether this possibility is excluded

experimentally. Quarks and antiquarks assignable to the nucleotide and its conjugate have opposite charges at the two sheets of the wormhole flux tube connective nucleotide to a lipid. Hence one could consider the possibility that a connection generated between them by reconnection mechanism could create Josephson junction.

2. The model for the photoreceptors leads to the identification of bio-photons as Josephson radiation and suggests that Josephson radiation propagates along flux tubes assignable to the cell membranes along sensory pathways up to sensory cortex and from there to motor cortex and back to the muscles and regenerates induced neuronal sensory experiences.

3. Josephson radiation could be used quite generally to communicate sensory data to/along the magnetic body: this would occur in the case of cell membrane magnetic body at least. The different resting voltages for various kinds of cells would select specific Josephson frequencies as communication channels.

4. If motor action indeed involves negative energy signals backwards in geometric time as Libet's findings suggest, then motor action would be very much like sensory perception in time reversed direction. The membrane resting potentials are different for various types of neurons and cells so that one could speak about pathways characterized by Josephson frequencies determined by the membrane potential. Each ion would have its own Josephson frequency characteristizing the sensory or motor pathway.

The basic questions concern the function of cyclotron radiation and whether Josephson radiation induces resonantly cyclotron radiation or vice versa.

1. Cyclotron radiation would be naturally associated with the flux sheets and flux tubes. The simplest hypothesis is that at least the magnetic field $B_{end} = .2$ Gauss can be assigned with the some magnetic flux quanta at least. The model for hearing suggests that B_{end} is in this case quantized so that cyclotron frequencies provide a magnetic representation for audible frequencies. Flux quantization does not pose any conditions on the magnetic field strength if the above discussed general flux quantization condition involving charged currents at the boundary of the flux quantum are assumed. If these currents are not present, $1/\hbar$ scaling of B_{end} for flux tubes follows.

2. The assumption that cyclotron radiation is associated with the motor control via genome is not consistent with the vision that motor action is time reversed sensory perception. It would also create the unpleasant question about information processing of the magnetic body performed between the receival of sensory data and motor action.

3. The notion of magnetic sensory canvas suggests a different picture. Josephson radiation induces resonant cyclotron transitions at the magnetic body and induces entanglement of the mental images in brain with the points of the magnetic body and in this manner creates sensory maps giving a third person perspective about the biological body. There would be two kind of sensory maps. Those assignable to the external world and those assignable to the body itself. The Josephson radiation would propagate along the flux tubes to the magnetic body.

4. There could be also flux tube connections to the outer magnetosphere of Earth. It would seem that the reconnections could be flux tubes traversing through inner magnetosphere to poles and from there to the outer magnetosphere. These could correspond to rather low cyclotron frequencies. Especially interesting structure in this respect is the magnetic flux sheet at the Equator.

6.7.5   Dark Matter Hierarchies Of Josephson Junctions

The hierarchy of Josephson junctions assignable to cell membrane and characterized by values of Planck constant provides a rather nice model for cell membrane but one can consider also more general dark hierarchies of Josephson junctions. This model conforms with the general vision that living matter processes information by locating it to various pages of the "Big Book".

Maximization of Planck constant in quantum control and communication in living matter

The sectors of the embedding space for which CD and CP_2 are replaced with their n_a- *resp.* n_b-fold coverings define the most promising candidates concerning the understanding of living matter, at least the quantum control of living matter. The reason is that the value of the Planck constant is maximized and given by $r = \hbar/\hbar_0 = n_a n_b$. Also the number of pages with same Planck constant would be finite unlike for the more general option allowing rational values of Planck constant. In particular, infinite number of pages with the standard value of Planck constant would be possible and this might lead to mathematical difficulties.

Experimental constraints allow to consider also the possibility that only covering spaces are possible. One must be however very cautious in making hasty conclusions. If also factor spaces are allowed one can have G_a or G_b as discrete and exact symmetry groups at the level of dark matter and these symmetries would be manifested as approximate symmetries of the visible matter topologically condensed around the dark matter.

1. In M^4 degrees of freedom since the restriction to the orbifold $\hat{M}^4/G_a$ is equivalent to the exact G_a-invariance of dark matter quantum states. Molecular rotational symmetries correspond typically to small groups G_a and might relate to this symmetry. Small values of n_a would not affect dramatically the value of Planck constant if n_b is large.

2. $G_a = Z_n$, $n = 5, 6$ are favored for molecules containing aromatic cycles. Also genuinely 3-dimensional tetrahedral, octahedral, and icosahedral symmetries appear in living matter.

In the sequel only integer values of Planck constant will be considered. An especially interesting hierarchy corresponds to ruler and compass integers expressible as a product of power of two and distinct Fermat primes (see Appendix). The reason is that these integers correspond to number theoretically very simple quantum phases. This hierarchy includes as a special case powers of two and one can imagined a resonant interaction between p-adic length scale hierarchy and hierarchy of Planck constants.

Dark hierarchy of Josephson junctions with a constant thickness

The model for EEG relies on fractal hierarchy of cell membrane like structures with a fixed thickness and membrane potential. Therefore cell membrane thickness is not scaled by $\hbar$ as one might naïvely expect. Same applies to magnetic flux tubes: this is possible since the condition for the quantization of magnetic flux can be replaced with a more general one if one allows charged currents at the boundaries of flux quanta [K91]. In this model the value of $\hbar$ becomes a measure for the evolutionary level of cell and neurons in hippocampus, associative regions of cortex and their motor counterparts, and frontal lobes are expected to correspond to the largest values of $\hbar$ measuring also the time scale of long term memory and planned action. Note that cell membrane corresponds to twin primes $k = 149$ and $k = 151$ with $k = 151$ defining a Gaussian Mersenne so that it is indeed very special.

Page of a book is rather precise metaphor for the magnetic flux sheet going through a linear array of strings of nuclei and also for a collection flux tubes parallel to axons. This raises several questions. Do the lines of the text of this book correspond to axons in neural circuits? Do the pages correspond to larger structures formed by the axons?

The quantum model for qualia [K91] implies that Josephson radiation travels through flux tubes parallel to sensory pathways and there could be also a horizontal organization of the neurons- at least at the level of sensory receptors in the sense that magnetic flux tubes connecting DNA nucleotides to lipids of cell membrane fuse to form longer flux tubes between DNA nucleotides of different cells when sensory receptor is active. Axons could thus be seen as the analogs of text lines which however can interact with each other. Similar organization would appear at the level of flux sheets traversing through DNA strands.

Books are made for reading and one can thus ask whether the book metaphor extends. Could the observed moving brain waves scanning cortex relate to the "reading" of the information associated with these sheets of book by the magnetic body and does our internal speech correspond to this "reading" ? One is also forced to ask whether these brain waves are induced by waves

$(k, k+2)$	$(137, 139)$	$(149, 151)$	$(167, 169 = 13^2)$	$(179, 181)$
$L_e(k)$	.78 A	5 nm	2.5μm	.32 mm
$(k, k+2)$	$(191, 193)$,	$(197, 199)$		
$L_e(k)$	1 cm	8 cm		

Table 6.6: Twin primes define especially interesting candidates for double membrane like structures defining Josephson junctions. Also included the pair $(137, 13^2 = 169)$ although $k = 169$ is not prime. The two largest scales could relate to structures appearing in brain.

propagating along magnetic flux quanta of the magnetic body of Earth or personal magnetic body in the case that it has components other than magnetic flux sheets serving as Josephson junctions.

An objection against a fractal hierarchy of Josephson junctions with thickness scaling as $\hbar$

One can consider also a hierarchy of Josephson junctions with a scaled up thickness proportional to $\hbar$ instead of constant thickness. If these junctions have same voltage at all levels of the hierarchy a resonant interaction between various levels of the hierarchy would become possible.

One can represent common sense objections against this idea. The electric field involved with the higher levels of Josephson junction hierarchy is very weak: something like 10^{-7} V/m for lito-ionospheric Josephson junctions (of thickness about 176 km from the scaling of the cell membrane thickness by $\lambda^4 = 2^{44}$) which might be responsible for EEG. The electric field of the Earth at space-time sheets corresponding to ordinary matter is much stronger: about $10^2 - 10^4$ V/m at the surface of Earth but decreasing rapidly as ionosphere is approached being about .3 V/m at 30 km height. The estimate for the voltage between ionosphere and Earth surface is about 200 kV [F5].

The many-sheeted variant of Faraday law implies that on order to have a voltage of order .08 V over lito-ionospheric Josephson junction at dark matter space-time sheet, the voltage over ionospheric cavity must be almost completely compensated by an opposite voltage over litosphere so that lito-ionospheric double layer could be seen as a pair of capacitor plates in a radial electric field of order 10^{-7} V/m generated by the charge density in sub-litospheric part of Earth. This condition requires fine-tuning and therefore looks unrealistic.

A natural distance scale in which the electric field is reduced would correspond to 10-20 km thick layer in which whether phenomena are present. The mirror image of this layer would be Earth's crust. The cell membrane counterpart would be a dipole layer like charge density between the lipid layers of the cell membrane. Note that the electric field at dark matter space-time can be constant. However, as far as Josephson junction is considered, it is only the net voltage what matters.

6.7.6   P-Adic Fractal Hierarchy Of Josephson Junctions

p-Adic length scale hypothesis allows to imagine a hierarchy of Josephson junctions at least in length scales regarded usually as biologically relevant. The voltage through the junction need not however be same as for the ordinary cell membrane anymore. Twin primes are especially interesting since they would naturally correspond to pairs of structures analogous to a pair of lipid layers defining cell membrane.

In particular, twin primes abundant in the p-adic length scale range assignable to living matter could define double layered structures acting as Josephson junctions.

Also Gaussian Mersennes define highly interesting p-adic length scales and the length scale range between cell membrane thickness and the size of cell contains as many as four Gaussian Mersennes corresponding to $k = 151, 157, 163, 167$. Only the smallest one is associated with a twin prime but p-adic length scale hypothesis allows also non-prime values of k.

The possibility of a p-adic hierarchy of membrane like structures accompanied by Josephson junctions

One can imagine the existence of fractally scaled up variants of cell membrane defining hierarchy of Josephson junctions possibly realized as magnetic flux tubes. The possible existence of this hierarchy is however not relevant for the model of EEG in its recent form.

The first hierarchy correspond to the p-adic length scales varying in the range of biologically relevant p-adic length scales $L(k)$ involving membrane like structures. Twin primes $(k, k+2)$ are good candidates here (Table 3). Second hierarchy corresponds to dark matter hierarchy for which length scales come as $\sqrt{r}L(k))$, $r = \hbar/\hbar_0$. Later the question which values of r are favored will be discussed.

The size of cell nucleus varies in the range $(L(169) = 5\ \mu m, 2L(169) = 10\ \mu m)$. This is consistent with the assumption that cell nucleus provides the fundamental representation for this block. This would mean that at least the multiply coiled magnetic flux quantum structures associated with DNA appear as fractally scaled up copies.

Each dark matter level corresponds to a block of p-adic length scales $L(k)$, $k = 151, ..., 169$. Also new length scales emerge at given level and correspond to $L(k)$, $k > 169$. The dark copies of all these length scales are also present. Hence something genuinely new would emerge at each level.

Fractal hierarchy of magnetic bodies assignable to cell

Second hierarchy corresponds to a dark matter hierarchy involving values of Planck constant. The original hypothesis was that the values of Planck constant comes as $r \equiv \hbar/\hbar_0 = 2^{11k}$ of given p-adic length scale assignable to biological membrane like structure. A possible justification for the hypothesis is that the ratio of electron and proton masses is rather near to 2^{11} and that this number appears in quantum TGD in the role of fundamental constant. This hypothesis is however un-necessarily restrictive and it is better to consider at least the values of r given as products of two ruler and compass integers n_F expressible as a product of distinct Fermat primes and some power of two. The justification comes from the number theoretic vision about evolution and number theoretical simplicity of the phases $q = exp(i2\pi/n_F)$ (Appendix).

The emergence of a genuinely new structure or function in evolution would correspond to the emergence of new level in this fractal hierarchy. Quantum criticality would be essential: phases corresponding different values of Planck constant would compete at quantum criticality.

The flux sheet or tubes through cell membranes should integrate to larger structures at the higher levels of dark matter hierarchy implying the integration of sensory inputs from a large number of cells to single coherent input at higher levels of dark matter hierarchy. One can think two options: the sensory inputs from cell membranes are communicated directly to the magnetic body or via the DNA. The second option would require that the flux sheets or tubes starting from cell membrane traverse also the DNA.

Chapter 7

Quantum Model for Bio-Superconductivity: II

7.1 Introduction

The models for EEG and its variants and for nerve pulse rely on a general model of high T_c superconductivity [K25, K26]. In this chapter the general vision behind model of cell membrane as super-conductor inspired by the identification of dark matter in terms of hierarchy of Planck constants and the notion of magnetic body considered in the previous chapter is tested by applying it to various anomalous findings about the behavior of the cell membrane.

7.1.1 Exotic Charge Transfer Between Cell Interior And Exterior As Fundamental Control Mechanism

The notions of ionic channels and pumps associated with the cell membrane are central for the standard cell biology [I128]. There are however puzzling observations challenging this dogma and suggesting that the currents between cell interior and exterior have quantum nature and are universal in the sense that they not depend on the cell membrane at all [I96, I64, I44, I137, I62]. One of the pioneers in the field has been Gilbert Ling [I96]. who has devoted for more than three decades to the problem, developed ingenious experiments, and written several books about the topic. The introduction of the book [I91]) gives an excellent layman summary about the paradoxical experimental results.

One can imagine several charge transfer mechanisms.

1. Ionic supra currents and Josephson currents define the first candidate for exotic charge transfer. The experimental data led to a model for cell homeostasis as a flow equilibrium in which very small densities of super-conducting ions (also molecular ions) and ionic supracurrents at cellular and other super-conducting space-time sheets dictate the corresponding densities at the atomic space-time sheets.

2. The most feasible model for cell membrane and charge transfer found hitherto relies on Pollack's observations about fourth gel like phase of water. The model for the findings leads to a generalization of the cell membrane as Josephson junction obtained by adding to Josephson energy the difference of the cyclotron energies of dark ion at two sides of the cell membrane. Cyclotron energy difference replaces chemical potential difference in the generalization of the thermodynamical model inspired by Zero Energy Ontology, and replacing thermodynamical distributions with their quantal "square roots". Charge transfer would be induced by a phase transition changing the value of Planck constant at either or both sides of the membrane. This would induce the change of the equilibrium concentrations of ions and also charge transfer.

3. I have also considered the exchange of exotic W bosons as a non-local charge transfer mechanism involving quantum entanglement in an essential way. Z^0 super-conductivity possible

for almost vacuum extremals in principle allows to generalize the model also to the control of the densities of neural atoms and molecules at atomic space-time sheets.

This control mechanism need not be the only one. Magnetic flux tubes serving as colored braid strands connecting different bio-molecules in highly selective way and phase transitions reducing or increasing $\hbar$ could explain the mysterious precision of bio-catalysis as how the prebiotic evolution has led to the known biology [K5]. Magnetic flux tubes could also act as Josephson junctions between widely separated structures.

7.1.2   Further Experimental Findings

There are further experimental findings giving support for the TGD based vision about living cell. The following findings are discussed.

1. Mainstream scientists refuse often to take seriously water memory and homeopathy using arguments which do not tolerate daylight. There is rich amount of evidence that water is able to store information about diluted molecules even at the limit of vanishing dilution [K53]. The explanation is of course that water somehow stores the information about molecules instead of molecules (this kind of explanation should be easy to discover at the computer era but the simplistic argument of skeptics is that those taking seriously water memory are crackpots not able to realize that the density of molecules after the preparation of homeopathic remedy is vanishingly small!). The notion of magnetic body and Pollack's findings about fourth phase of water inspired TGD based model of water memory. The emergence of vertebrate genetic code in the model of dark proton and nuclei allows even the possibility that exclusion domains of Pollack define primitive life forms.

2. Chiral selection of bio-molecules is one of the basic mysteries of biology. Dark matter realized in terms of a hierarchy of Planck constants suggests that electroweak physics could appear as scaled up dark and also ordinary copies in various preferred p-adic length scales. Below the Compton lengths dark and p-adically scaled-up weak bosons would behave like massless particles implying that weak interactions have same strength as electromagnetic interactions so that parity breaking effects caused by the axial couplings of weak bosons would be large and could explain chiral selection.

3. The observation that the irradiation of water by radiowaves "burns" water by inducing a visible flame is not easy to understand ins standard physics framework. If the radio waves involves dark photons with large enough Planck constant, the high energy of radiowave photons induce large energy transfer to the water and can induce the effect.

7.1.3   Evidence For Axonal Supra Currents

Hafedh Abdelmelek and collaborators [J34] have found evidence for effective super-conductivity in the sciatic nerves of both endotherms (rabbit) and poikilotherms (frog). The basic finding is that the resistance of the sciatic nerve is reduced by a factor of about ten below a critical temperature at the lower edge of the range of the physiological temperatures. The reduction of the temperature occurs inside a narrow temperature range ΔT, $\Delta T/T_c \sim .04$. This suggests effective super-conductivity. Furthermore, the critical temperature T_c for the breaking of the effective super-conductivity raises from 240 K to 300 K in the transition from poikilotherms (say frog) to endotherms (say rabbit). A TGD inspired model for these currents is discussed.

7.1.4   DC Currents Of Becker

Robert Becker [J24] proposed on basis of his experimental work that living matter behaves as a semiconductor in a wide range of length scales ranging from brain scale to the scale of entire body. Direct currents flowing only in preferred direction would be essential for the functioning of living way in this framework.

   One of the basic ideas of TGD inspired theory of living matter is that various currents, even ionic currents, are quantal currents. The first possibility is that they are Josephson currents

associated with Josephson junctions but already this assumption more or less implies also quantal versions of direct currents.

A TGD inspired model for quantal direct currents is proposed and its possible implications for the model of nerve pulse are discussed.

7.1.5   Two Views About Cell Membrane

I have considered two possible views about cell membrane. First view might apply to sensory receptors and involves in an essential way the classical Z^0 fields which could be present even in cellular length scales if the hierarchy of Planck constants is realized. Second view is inspired by Pollack's findings.

Could cell membrane correspond to almost vacuum extremal?

The question whether cell membrane or even cell could correspond almost vacuum extremal of Kähler action (in some cases) was the question which led to the realization that the frequencies of peak sensitivity for photoreceptors correspond to the Josephson frequencies of biologically important ions if one accepts that the value of the Weinberg angle equals to $sin^2(\theta_W) = .0295$ instead of the value .23 in the normal phase, in which the classical electromagnetic field is proportional to the induced Kähler form of CP_2 in a good approximation. It has however become clear that the argument fixing the value of Weinberg angle is however rather weak. The assumption that the membrane potentials through receptors are different for biologically important ions and their Cooper pairs allows to reproduce the photon energies which are absorved maximally by photoreceptors.

Another implication made possible by the large value of Planck constant is the identification of Josephson photons as the counterparts of bio-photons one one hand and those of EEG photons on the other hand. These observation in turn led to a detailed model of sensory qualia and of sensory receptor.

Pollack's findings about fourth phase of water

Pollack and Zheng discovered what they call exclusions zone in water. Exclusion zone is negatively charged and has rather intriguing properties suggesting its biological relevance. I have considered this finding in TGD context for few years ago and decided to keep the proposed model as an example about how ideas develop. I also discuss the recent model inspired by the lecture of Pollack [L23] about the fourth phase of water.

The discovery of negatively charged exclusion zone formed in water bounded by gel phase was the motivation for Pollack to propose the notion of gel like fourth phase of water.

The TGD inspired proposal is that the fourth phase corresponds to negatively charged regions - exclusion zones - with size up to 100-200 microns generated when energy is fed into the water - say as radiation, in particular solar radiation. The stoichiometry of the exclusion zone is $H_{1.5}O$ and can be understood if every fourth proton is dark proton residing at the flux tubes of the magnetic body assignable to the exclusion zone and outside it. This leads to a model for prebiotic cell as exclusion zone. Dark protons are proposed to fork dark nuclei whose states can be grouped to groups corresponding to DNA, RNA, amino-acids, and tRNA and for which vertebrate genetic code is realized in a natural ways [K53, L3]. The voltage associated with the system defines the analog of membrane potential, and serves as a source of metabolic energy as in the case of ordinary metabolism. The energy is liberated in a reverse phase transition in which dark protons transform to ordinary ones. Dark proton strings serve as analogs of basic biopolymers, and one can imagine analog of bio-catalysis with enzymes replaced with their dark analogs. The recent discovery that metabolic cycles emerge spontaneously in absence of cell support this view.

This leads to a model of cell membrane as a generalized Josephson junction. Generalized Josephson energy is identified as the sum of the Coulombic part and difference of cyclotron energies at the two sides of the cell membrane. Zero energy ontology inspires a model of cell membrane defined as "square root" of the thermodynamical model of cell membrane. This leads to the identification of EEG and its variants in terms of dark photons with generalized Josephson energies. Biophotons would result as decay produces of these dark photons. This model allows generalization to the case of almost vacuum extremal.

7.1.6   Implications Of Strong Gravimagnetism For TGD Inspired Quantum Biology

Physicists M. Tajmar and C. J. Matos and their collaborators working in ESA (European Satellite Agency) have made an amazing claim of having detected strong gravimagnetism with gravimagnetic field having a magnitude which is about 20 orders of magnitude higher than predicted by General Relativity.

Tajmar *et al* have proposed the gravimagnetic effect as an explanation of an anomaly related to the superconductors. The measured value of the mass of the Cooper pair is slightly larger than the sum of masses whereas theory predicts that it should be smaller. The explanation would be that actual Thomson field is larger than it should be because of gravimagnetic contribution to quantization rule used to deduce the value of Thomson field. The required value of gravimagnetic Thomson field is however 28 orders of magnitude larger than General Relativity suggests. TGD inspired proposal is based on the notion of gravitational Planck constant assignable to the flux tubes connecting to massive objects. It turns out that the TGD estimate for the Thomson field has correct order of magnitude. The identification $h_{eff} = h_{gr}$ at particle physics and atomic length scales emerges naturally.

A vision about the fundamental role of quantum gravitation in living matter emerges. The earlier hypothesis that dark EEG photons decay to biophotons with energies in visible and ultraviolet range receives strong quantitative support. Also a mechanism for how magnetic bodies couple bio-chemistry emerges. The vision conforms with Penrose's intuitions about the role of quantum gravity in biology.

The appendix of the book gives a summary about basic concepts of TGD with illustrations. Pdf representation of same files serving as a kind of glossary can be found at `http://tgdtheory.fi/tgdglossary.pdf` [L18].

7.2   Exotic Charge Transfer Between Cell Interior And Exterior As Fundamental Control Mechanism

The notions of ionic channels and pumps associated with the cell membrane are central for the standard cell biology [I128]. There are however puzzling observations challenging this dogma and suggesting that the currents between cell interior and exterior have quantum nature and are universal in the sense that they not depend on the cell membrane at all [I96, I64, I44, I137, I62]. One of the pioneers in the field has been Gilbert Ling [I96], who has devoted for more than three decades to the problem, developed ingenious experiments, and written several books about the topic. The introduction of the book [I91]) gives an excellent layman summary about the paradoxical experimental results.

It was a pleasant surprise to find that these experimental findings give direct support for the existence of an exotic charge transfer between cell interior and exterior.

Ionic supra currents and Josephson currents or the exchange of exotic W bosons could be in question. For the first option, the experimental data led to a model for cell homeostasis as a flow equilibrium in which very small densities of super-conducting ions (also molecular ions) and ionic supercurrents at cellular and other super-conducting space-time sheets dictate the corresponding densities at the atomic space-time sheets. Z^0 super-conductivity possible for almost vacuum extremals in principle allows to generalize the model also to the control of the densities of neural atoms and molecules at atomic space-time sheets.

This control mechanism need not be the only one. Magnetic flux tubes serving as colored braid strands connecting different bio-molecules in highly selective manner and phase transitions reducing or increasing $\hbar$ could explain the mysterious precision of bio-catalysis as how the prebiotic evolution has led to the known biology [K5]. Magnetic flux tubes could also act as Josephson junctions between widely separated structures.

7.2.1   Strange Behavior Of The Intracellular Water

The basic strange feature of cellular interior is related to its gelatinous nature and is in fact familiar for everyone. Although 80 percent of hamburger is water, it is extremely difficult to extract this

water out. Ling [I64] has demonstrated this at cellular level by using a centrifuge and cells for which cell membrane is cut open: centrifugal accelerations as high as 1000 g fail to induce the separation of the intracellular water.

The assumption that cytoplasm behaves like gel explains these findings. Egg is very familiar example of gel phase so that this proposal could have been made already by the pioneers. The dipolar nature of bio-molecules and induced polarization are basis prerequisites for the formation of gels. Ling raises the cohesion between water and protein molecules caused by electric dipole forces as a fundamental principle and calls this principle association-induction hypothesis [I96]. This cohesion gives rise to liquid [F6] [D4] like structure of water implying among other things layered structures and internal electric fields orthogonal to the plane of the layers [I112, I102, I96] . For instance, cell membranes can be understood as resulting from the self-organization of liquid crystals [K27]. The fundamental importance of electret nature of biomatter was also realized by Fröhlich [J80] and led him to suggest that macroscopic quantum phases of electric dipoles might be possible. This concept, which is in central role in many theories of quantum consciousness, has not been established empirically.

7.2.2   Are Channels And Pumps Really There?

Standard neurophysiology relies strongly on the concepts of what might be called hydro-electro-chemistry. The development of the theory has occurred through gradual improvements saving the existing theory.

The development began from the basic observation that cells are stable gelatinous entities not mixing with the surrounding water. This led to the hypothesis that cell membrane takes care that the contents of the cell do not mix with the cell exterior. It was however soon found that cell membrane allows some ions to flow through. The interaction between theory and experiment led gradually to the notions of ion channel and ion pump, which are still central for the standard paradigm of the cell [I128]. Note that also "electric pump" taking care that membrane potential is preserved, is needed.

These notions developed gradually during the period when cell was seen as a bag containing water and a mixture of various biochemicals. If cell biology would have started to develop during the latter half of this century and after the discovery of DNA, cell as a computer metaphor might have led to a quite different conceptualization for what happens in the vicinity of the cell membrane. Also the notion of liquid crystals [D4] would have probably led to different ideas about how homeostasis between cell interior and exterior is realized [I112, I102, I96].

For me it was quite a surprise to find that pump-channel paradigm is not at all so well-established as I had believed as an innocent and ignorant outsider. The first chapter of the book "Cells, Gels and the Engines of Life" of Gerald Pollack [I91] provides a summary about the experimental paradoxes (the interested reader can find the first chapter of this book from web).

The standard theoretical picture about cell is based on the observation that cell exterior and interior are in a relative non-equilibrium. The measured concentrations of various atomic ions and organic molecules are in general different in the interior and exterior and cell membrane seems to behave like a semi-permeable membrane. There is also a very strong electric field over the cell membrane. In standard approach, which emerged around 1940, one can understand the situation by assuming that there are cell membrane pumps pumping ions from cell interior to exterior or vice versa and channels through which the ions can leak back. Quite a many candidates for proteins which seem to function like pump and channel proteins have been identified: even a pump protein for water [I91] ! This does not however prove that pumping and channelling is the main function of these proteins on the case of basic biological ions or that they have anything to do with how ionic and molecular concentrations in the interior and exterior of the cell are determined. It could quite well be that in the case of basic ions pump and channel proteins are receptors involved with the transfer of information rather than charges and only effectively act as pumps and channels.

There are several serious objections of principle against the vision of cell as a bag of water containing a mixture of chemicals. Even worse, the hypothesis seems to be in conflict with experimental data.

Selectivity problem

Cell membrane is extremely selective and this leads to an inflation in the complexity of channels and pumps. The problem might be christened as a dog-door problem: the door for dog allows also cat go through it. Channels cannot be simple sieves: it is known that channels which let some ions through do not let much smaller ions through. There must be more complicated criteria than geometric size for whether the channel lets the ion go through. Quite generally, channels must be highly selective and this seems to require complicated information processing to decide which ion goes through and which not. As a consequence, the models for channels inflate in their complexity.

The only reasonable way to circumvent the problem is to assume that there is kind of binary coding of various chemical compounds but it is difficult to see how this could be achieved in the framework of the standard chemistry. The notion of fractional atom proposed in [K45] to give rise to the emergence of symbols at the level of biochemistry could however allow this kind of coding. Channels and pumps (or whatever these structures actually are) could be also generated by self-organization process when needed.

Inflation in the number of pumps and channels

Channels and pumps for atomic ions and channels and pumps for an astronomical number of organic molecules are needed. The first question is where to put all those channels and pumps? Of course, one could think that pumps and channels are constructed by the cell only when they are needed. But how does the cell know when a new pump is needed if the cell as never met the molecule in question: for instance, antibiotic or curare molecule?

To realize how weird the picture based on channels and pumps is, it is useful to imagine a hotel in which there is a door for every possible client letting only that client through but no one else. This strange hotel would have separate door for every five point five milliard humans. Alternatively, the building would be in a continual state of renovation, new doors being built and old being blocked.

There is however an TGD based objection against this slightly arrogant argument. In TGD framework cell is a self-organizing structure and it might be that there is some mechanism which forces the cell to produce these pumps and channels by self-organization. Perhaps the basic characteristic of quantum control in many-sheeted space-time is that it somehow forces this kind of miracles to occur.

Why pumping does not stop when metabolism stops?

One can also wonder how metabolism is able to provide the needed energy to this continual construction of pumps and channels and also do the pumping. For instance, sodium pump alone is estimated to take 45-50 per cent of the cell's metabolic energy supply. Ling has studied the viability of the notion of the ionic pump experimentally [I96] by exposing cell to a coctail of metabolic poisons and depriving it from oxygen: this should stop the metabolic activities of the cell and stop also the pumping. Rather remarkably, nothing happened to the concentration gradients! Presumably this is the case also for the membrane potential so that also the notion of metabolically driven electrostatic pumps seems to fail. Of course, some metabolism is needed to keep the equilibrium but the mechanism does not seem to be a molecular mechanism and somehow manages to use extremely small amount of metabolic energy.

How it is possible that ionic currents through silicon rubber membrane are similar to those through cell membrane?

A crucial verification of the channel concept was thought to come in the experiment of Neher and Sakmann [I138] (which led to a Nobel prize). The ingenious experimental arrangement was following. A patch of membrane is sucked from the cell and remains stuck on the micropipet orifice. A steady voltage is applied over the patch of the membrane and the resulting current is measured. It was found that the current consists of discrete pulses in consistency with the assumption that a genuine quantum level current is in question. The observation was taken as a direct evidence for the postulate that the ionic currents through the cell membrane flow through ionic channels.

The later experiments of Fred Sachs [I137] however yielded a complete surprise. Sachs found that when the patch of the cell membrane was replaced by a patch of silicon rubber, the discrete currents did not disappear: they remained essentially indistinguishable from cell membrane currents! Even more surprisingly, the silicon rubber membrane showed ion-selectivity features, which were essentially same as those of the cell membrane! Also the currents through synthetic polymer filters [I62] were found to have essentially similar properties: as if ion selectivity, reversal potential, and ionic gating would not depend at all on the structure of the membrane and were more or less universal properties. Also experiments with pure lipid-layer membranes [I44] containing no channel proteins demonstrated that the basic features – including step conductance changes, flickering, ion selectivity, and in-activation– characterized also cell membranes containing no ionic channels.

The in-escapable conclusion forced by these results seems to be that the existing 60-year old paradigm is somehow wrong. Ionic currents and the their properties seem to be universal and depend only on very weakly on the properties of the membrane. This conclusion need not apply to the currents of polar molecules for which genetically coded pump and channel proteins certainly exists. Neither does it imply that pumps and channels could not be used to achieve a more efficient transfer of ions. Pump - and channel proteins seem to be a well-established notion and TGD approach suggests that they serve as Josephson junctions.

This however requires a generalization of the ordinary thermodynamical approach to cell membrane by starting from zero energy ontology and replacing Boltzmann weight with the complex square roots. Chemical potentials giving dominant part to the change of energy as it goes through cell membrane is replaced with the difference of cyclotron energy which is in visible and UV range from the condition that dark EEG photons have energies of bio-photons [K44]. One ends up with a generalization of Josephson junction: the generalized Josephson energy includes besides Coulombic energy difference also the cyclotron energy difference. Dark cyclotron contribution raises the energy scale of.05-.1 eV associated with cell membrane to.5-10 eVs and one can understand the nominal value.5 eV of metabolic energy currency.

7.2.3   Cytoplasm As Gel

The solution to the above described anomalies proposed by Pollack is that cytoplasm is gel phase [I91]. Pollack describes in detail various aspects of cytoplasm as a gel phase and here only short summary can be given.

1. Cytoplasm can be regarded as a network consisting of cross-linked negatively charged proteins. Water is condensed around the proteins to form structured water. If protein is hydrophilic, water self-organizes around it as a multilayered structure: the number of molecular layers can as high as 600 and the thickness of the layered structure is a considerable fraction of micrometer. If the protein is hydrophobic, water forms another structured phase known as clathrate water: in this case the number of hydrogen bonds between water atoms is large. These phases can be regarded as intermediate between ice and water. Also ordinary ions have this kind of layered structure around them. Chemical cross-links tend to be stable with heat, pH, and solvent composition whereas physical cross-links formed by intermolecular interactions are sensitive to environmental interactions and are of special interest from the point of view of phase transitions.

2. Pollack proposes that the formation of polymers takes place in an environment containing layered water for the simple reason that monomers cannot diffuse to the layered water so that the probability of association with the end of the growing polymer increases.

3. Cell interior is populated by micro-tubules, various filamentary structures, and the so called micro-trabecular matrix. Micro-trabecular network divides cell into a compartments in such a manner that the typical distance between two proteins in water is about 5 nm: this corresponds to the p-adic length scale $L(149)$, the thickness of the lipid layer of cell membrane. This is probably not an accident and the micro-trabecular network might be closely involved with the highly folded network of intracellular membranes. There would be a layer of thickness of about 6 water molecules per given protein surface so that a dominating portion of intracellular water could be structured.

4. The layered water has several tell-tale signatures that have been observed in gels. It freezes at much lower temperature than ordinary water; various relaxation times are shorter since the energy transfer to the water lattice occurs faster than to non-structure water; the diffusion rates of particles into the structured water are much slower than to ordinary water by entropy argument; a simple geometric argument tells that the larger the size of the hydrated ion the lower the diffusion rate; strong gradients of ionic concentrations can form in gel phase as has been observed.

The identification of the cytoplasm as a gel has profound implications for the standard views about cell.

1. The original motivation for postulating semipermeable cell membrane, channels, and pumps was the need to hinder the diffusion of various ions between cell interior and exterior taking place if cytoplasm is ordinary water into which molecules are dissolved. If cytoplasm is in gel phase, cell membrane need not perform pumping and channeling anymore except perhaps in situations involving the formation of a local sol phase. This raises the question about the proper functions of the cell membrane.

2. It is possible to drill to cell membrane holes with size of order 1 μm without an appreciable effect on the functioning of the cell and also show that these holes remain as such for long periods of time [I91]. It is also possible to splice cells into pieces continuing to function for days. That K^+ flux through cell membrane does not change when lipids are partially removed. These findings force to ask whether the assumption about the continuity of the cell membrane might be too strong [I91]. Electron micrographs however demonstrate the presence of the bi-layered structure. What is intriguing that this structure is seen even in the absence of lipid layers. In TGD framework this paradoxical finding might be understood in terms of a presence of space-time sheets corresponding to p-adic length scales $L(k)$, $k = 149, 151$ as vacuum structures predicted also by TGD inspired model of high T_c super-conductivity [K25].

3. There is also the strange finding that water flux through cell membrane is much higher than the flux through isolate lipid bi-layer as if some unidentified channels were present. In TGD framework this might be seen as an evidence for the presence of (wormhole) magnetic flux tubes as carriers of water molecules.

4. The fundamental assumptions about ionic equilibrium must be reconsidered, and the Hodkin-Huxley model for the generation of nerve pulse becomes more or less obsolete. Indeed, it has been found that action potentials can be generated even in absence of Na^+ and K^+ ions playing a key role in Hodkin-Huxley model. Rather remarkably, the high concentration of K^+ ions and low concentration of Na_+ ions in cytoplasm could be understood on basis of gel property only. Also new view about cell (note membrane-!) potential emerges. The standard paradigm states that the resting potential is over the cell membrane. Potentials of same order of magnitude have been however seen in de-membraned cells (50 mV in slight excess of action potential and critical potential), colloidal suspensions, and gels which suggest that larger part of cell than mere cell membrane is involved with the generation of the action potential and one should thus speak of cell potential instead of membrane potential.

5. Pollack suggests that the phase transitions of the gel phase make possible to realize various functions at molecular and cellular level and represents empirical evidence for the phase transition like aspects assigned to these functions including sensitivity to various factors such as pH, temperature, chemical environment, electromagnetic fields, mechanical forces, etc... and the threshold behavior [I91]. Also the responses are typical for phase transitions in that they involve dramatic changes in volume, shape, di-electric constant, etc.. With these motivations Pollack discusses phase transition based models for contraction, motility, secretion, transport or molecules, organized flow of particles during cell division, cell locomotion, contraction of muscle, generation of action potentials, etc.. For instance, the transport of bio-molecules along micro-tubule could involve propagating gel-sol-gel phase transition meaning also propagating melting of the layered water around micro-tubule.

6. Divalent ions, such as Mg^{+2} and Ca^{+2} can act as cross links between negatively charged proteins binding them to form networks. Monovalent ions cannot do this. Peripheral cytoskeleton is this kind of network consisting of micro-tubules and actin molecules cross-linked - according to Pollack- by Ca^{+2} ions. On the other hand, it is known that Mg^{+2} (Ca^{+2}) ions dominate in the cell interior (exterior) and that the presence of Ca^{+2} ions in the cell exterior is crucial the for generation of nerve pulse. The influx of Na^+ ions having higher affinity to proteins can induce a phase transition to sol-like phase. Pollack suggests a model of nerve pulse based on this mechanism of gel-sol phase transition for peripheral cytoskeleton: this model does not actually explain why Ca^{+2} ions in the exterior of axon are necessary.

7.2.4 TGD Based Vision Inspired By The Findings

The vision about dark matter and the model of nerve pulse formulated in terms of Josephson currents brings an additional perspective to the role of pumps and channels and allows to achieve harmony with the standard views about their role.

1. In long length scales visible matter forms roughly 5 per cent of the total amount of matter. In TGD Universe the dark matter would correspond to matter with large Planck constant including dark variants of ordinary elementary particles. In living matter situation could be the same and visible matter could form only a small part of the living matter. Dark matter would be however visible in the sense that it would interact with visible matter via classical electromagnetic fields and photon exchanges with photons suffering Planck constant changing phase transition. Hence one can consider the possibility that most of the biologically important ions and perhaps even molecules reside at the magnetic flux quanta in large $\hbar$ phase.

2. Bosonic ions could form Bose-Einstein condensates at the flux tubes in which case supra currents flowing without any dissipation would be possible. The model for high T_c superconductivity suggests that only electronic and protonic super-conductivity are possible at room temperature. If so, Cooper pairs of fermionic ions are excluded. New nuclear physics predicted by TGD could however come in rescue here. The TGD based model for atomic nucleus assumes that nuclei are strings of nucleons connected by color bonds having quark and antiquark at their ends. Also charged color bonds are possible and this means the existence of nuclei with anomalous charge. This makes possible bosonic variants of fermionic ions with different mass number and it would be interesting to check whether biological important ions like Na^+, Cl^-, and K^+ might actually correspond to this kind of exotic ions.

This leads to the following TGD inspired vision about cell as a gel.

1. DNA as TQC hypothesis and cell membrane as sensory receptor provide possible candidates for the actual functions of the cell membrane and ionic channels and pumps could act as kind of receptors. That standard physics is able to describe gel phase is of course a mere belief and (wormhole) magnetic flux tubes connecting various molecules (DNA, RNA, amino-acids, biologically important ions) would be "new physics" cross-links could explain the strong correlations between distant molecules of the gel phase.

2. Dark ionic currents are quantal currents. If the dark ions flow along magnetic or wormhole magnetic flux tubes connecting cell interior and exterior, their currents through cell membrane would be same as through an artificial membrane.

3. Pumps and channels could serve the role of sensory receptors by allowing to take samples about chemical environment. One cannot exclude the possibility that proteins act as pumps and channels in sol phase if magnetic flux tubes are absent in this phase since also in TGD Universe homeostasis and its control at the level of visible matter in sol phase might requires them. The metabolic energy needed for this purpose would be however dramatically smaller and a reliable estimate for this would allow an estimate of the portion of dark matter in living systems.

4. Quantum criticality suggests that the phase transitions for the gel phase are induced by quantum phase transitions changing the value of Planck constant for magnetic flux tubes and inducing the change of the length of the flux tube. Macroscopic quantum coherence would explain the observed co-operativity aspect of the phase transitions. Concerning loco-motion and transport mountain climbing using pickaxe and rope inspires a guess for a general mechanism. For instance, a packet of molecules moving along actin molecule or a molecule carrying a cargo along micro-tubule could repeat a simple basic step in which a magnetic flux tube with large $\hbar$ is shot along the direction of the electric field along micro-tubule and stuck to a rachet followed by a phase transition reducing the value of $\hbar$ and shortening the flux tube and forcing the cargo to move forward. The metabolic energy might be provided by the micro-tubule rather than molecular motor.

5. The reconnection of flux tubes would be a second phase transition of this kind. This phase transition could lead from a phase in phase proteins are unfolded with flux tubes connecting amino-acids to water molecules and thus possessing a large volume of layered water around them to a phase in which they become folded and flux tubes connect amino-acids to each other in the interior of protein. The phase transition could be associated with the contraction of connecting filaments of muscle cell. The phase transitions are also seen in "artificial protein" gels used for drug delivery applications, and are built from polymers arranged in alpha helices, beta sheets and common protein motifs [I91]. If wormhole magnetic flux are taken are taken as a basic prerequisite of life, one must ask whether these "artificial proteins" represent artificial life.

6. The fact that cytoskeleton rather than only cell membrane is involved with the generation of action potential conforms with the idea that nerve pulse propagating along axon involves also axonal micro-tubules and that Josephson currents between axon and micro-tubules are involved in the process.

7. Di-valent ions (Ca^{+2} ions according to Pollack) serve as cross links in the peripheral cy-toskeleton. The influx of monovalent ions from the exterior of axon induces gel-sol phase transition replacing di-valent ions with monovalent ions. One can consider two models.

   (a) The minimal assumption is that this phase transition is induced $\hbar$ increasing phase transition the flow of the monovalent ions like Na^+ from the cell exterior along the magnetic flux tubes connecting axonal interior and interior. Suppose that in the original situation the flux tubes end to axonal membrane (this is not the only possibility, they could also end to Ca^{+2} ions). The flux tubes extending to the axonal exterior could result by $\hbar$ increasing phase transition increasing the length of the flux tubes connecting peripheral cytoskeleton to the axonal membrane so that they extend to the exterior of axon. This option is rather elegant since gel-sol phase transition itself can be understood in terms of "standard chemistry". In this model the very slow diffusion rate of the ions to gel phase would have explanation in terms of new physics involving dark matter and (wormhole) magnetic flux tubes.

   (b) One can consider also an option in which divalent ions such as Ca^{+2} or Mg^{+2} are connected by two flux tubes to amino-acids of two negatively charged proteins whereas monovalent biological ions like Na^+ would have single flux tube of this kind and could not act as cross links. In the phase transitions removing the cross links the replacement of divalent ion with two monovalent positively charged ions would take place. If one believes in standard chemistry, Na^+ ions would flow in automatically. First the increase of Planck constant would induce the lengthening of the magnetic flux tubes and thus the expansion of the gel phase making possible the influx of monovalent ions. If Na^+ ions are dark, flux tubes connecting peripheral cytoskeleton to the axonal exterior are required and the mechanism of option i) is also needed.

8. The mechanisms i) and ii) could be fused to a single one. The hint comes from the presence of Ca^{+2} ions in the exterior of axon is necessary for the generation of action potential. The simplest possibility is that the flux tubes connecting proteins to intracellular Ca^{+2} cross links in gel phase connects them after the length increasing phase transition to extracellular Ca^{+2} ions and Na^+ ions flow along these flux tubes.

9. The increase of the Planck constant would induce the expansion of the peripheral cytoskeleton making possible the inflow of Na^+ ions, and divalent ions binding negatively charged actin molecules to a network would be replaced with inflowing Na^+ ions. After this a reverse phase transition would occur. Both phase transitions could be induced by a quantal control signal (Josephson current) inducing quantum criticality and a change of Planck constant.

10. A propagating Ca^{+2} wave inducing the gel-sol-gel phase transition of peripheral cytoskeleton would accompany nerve pulse. Quite generally, Ca^{+2} waves are known to play a fundamental role in living matter as kind of biological rhythms. Irrespective of whether one believes option a) or b), this might relate to the cross-linking by flux tubes and gel-sol-gel phase transitions induce by phase transitions increasing Planck constant temporarily. The velocities and oscillation periods of Ca^{+2} waves vary in an extremely wide range: this can be understood if the flux tubes involved correspond to a very wide spectrum of Planck constant.

Besides basic ions cell membrane is non-permeable to various polar molecules such as the basic building bricks of DNA and amino-acids. The safest assumption is that genetically coded pump and channel proteins make possible the transfer. One must of course consider the possibility that channels and pumps are used to make the transfer of basic ions more effective. Taking this into account, the proposed vision does not differ so radically from the standard one as one might think first and only the model for nerve pulse generation must be modified radically.

To sum up, the strange discoveries about the behavior of cell membrane provide direct experimental evidence for the presence of dark matter in living systems, for the prediction that it interacts with ordinary matter via classical electromagnetic fields, and for the assumption that it does not dissipate appreciably and could therefore have large value of $\hbar$ and form macroscopic quantum phases.

7.3 Further Experimental Findings

In this section I discuss further experimental findings giving support for the TGD based vision about living cell.

7.3.1 Genes And Water Memory

After long time I had opportunity to read a beautiful experimental article about experimental biology. Yolene Thomas, who worked with Benveniste, kindly sent the article to me. The freely loadable article is *Electromagnetic Signals Are Produced by Aqueous Nanostructures Derived from Bacterial DNA Sequences* by Luc Montagnier, Jamal Aissa, Stephane Ferris, Jean-Luc Montagnier, and Claude Lavall'e published in the journal Interdiscip. Sci. Comput. Life Sci. (2009) [I65].

Basic findings at cell level

I try to list the essential points of the article. Apologies for biologists: I am not a specialist.

1. Certain pathogenic micro-organisms are objects of the study. The bacteria Mycoplasma Pirum and E. Choli belong to the targets of the study. The motivating observation was that some procedures aimed at sterilizing biological fluids can yield under some conditions the infectious micro-organism which was present before the filtration and absent immediately after it. For instance, one filtrates a culture of human lymphocytes infected by M. Pirum, which has infected human lymphocytes to make it sterile. The filters used have 100 nm and 20 nm porosities. M. Pirum has size of 300 nm so that apparently sterile fluids results. However if this fluid is incubated with a mycoplasma negative culture of human lymphocytes, mycoplasma re-appears within 2 or 3 weeks! This sounds mysterious. Same happens as 20 nm filtration is applied to a a minor infective fraction of HIV, whose viral particles have size in the range 100-120 nm.

2. These findings motivated a study of the filtrates and it was discovered that they have a capacity to produce low frequency electromagnetic waves with frequencies in good approximation coming as the first three harmonics of kHz frequency, which by the way plays also a

central role in neural synchrony. What sounds mysterious is that the effect appeared after appropriate dilutions with water: positive dilution fraction varied between 10^{-7} and 10^{-12}. The uninfected eukaryotic cells used as controls did not show the emission. These signals appeared for both M. Pirum and E. Choli but for M. Pirum a filtration using 20 nm filter canceled the effect. Hence it seems that the nano-structures in question have size between 20 and 100 nm in this case.

A resonance phenomenon depending on excitation by the electromagnetic waves is suggested as an underlying mechanism. Stochastic resonance familiar to physicists suggests itself and also I have discussed it while developing ideas about quantum brain [K95]. The proposed explanation for the necessity of the dilution could be kind of self-inhibition. Maybe a gel like phase which does not emit radiation is present in sufficiently low dilution but is destroyed in high dilutions after which emission begins. Note that the gel phase would not be present in healthy tissue. Also a destructive interference of radiation emitted by several sources can be imagined.

3. Also a cross talk between dilutions was discovered. The experiment involved two tubes. Donor tube was at a low dilution of E. Choli and "silent" (and carrying gel like phase if the above conjecture is right). Receiver tube was in high dilution (dilution fraction 10^{-9}) and "loud". Both tubes were placed in mu-metal box for 24 hours at room temperature. Both tubes were silent after his. After a further dilution made for the receiver tube it became loud again. This could be understood in terms of the formation of gel like phase in which the radiation does not take place. The effect disappeared when one interposed a sheath of mu-metal between the tubes. Emission of similar signals was observed for many other bacterial specials, all pathogenic. The transfer occurred only between identical bacterial species which suggests that the signals and possibly also frequencies are characteristic for the species and possibly code for DNA sequences characterizing the species.

4. A further surprising finding was that the signal appeared in dilution which was always the same irrespective of what was the original dilution.

Experimentation at gene level

The next step in experimentation was performed at gene level.

1. The killing of bacteria did not cancel the emission in appropriate dilutions unless the genetic material was destroyed. It turned out that the genetic material extracted from the bacteria filtered and diluted with water produced also an emission for sufficiently high dilutions.

2. The filtration step was essential for the emission also now. The filtration for 100 nm did not retain DNA which was indeed present in the filtrate. That effect occurred suggests that filtration destroyed a gel like structure inhibiting the effect. When 20 nm filtration was used the effect disappeared which suggests that the size of the structure was in the range 20-100 nm.

3. After the treatment by DNAse enzyme inducing splitting of DNA to pieces the emission was absent. The treatment of DNA solution by restriction enzyme acting on many sites of DNA did not suppress the emission suggesting that the emission is linked with rather short sequences or with rare sequences.

4. The fact that pathogenic bacteria produce the emission but not "good" bacteria suggests that effect is caused by some specific gene. It was found that single gene - adhesin responsible for the adhesion of mycoplasma to human cells- was responsible for the effect. When the cloned gene was attached to two plasmids and the E. Choli DNA was transformed with the either plasmid, the emission was produced.

Some consequences

The findings could have rather interesting consequences.

1. The refinement of the analysis could make possible diagnostics of various diseases and suggests bacterial origin of diseases like Alzheimer disease, Parkinson disease, Multiple Sclerosis and Rheumatoid Arthritis since the emission signal could serve as a signature of the gene causing the disease. The signal can be detected also from RNA viruses such as HIV, influenza virus A, and Hepatitis C virus.

2. Emission could also play key role in the mechanism of adhesion to human cells making possible the infection perhaps acting as a kind of password.

The results are rather impressive. Some strongly conditioned skeptic might have already stopped reading after encountering the word "dilution" and associating it with a word which no skeptic scientist in his right mind should not say aloud: "homeopathy" ! By reading carefully what I wrote above, it is easy to discover that the experimenters unashamedly manufactured a homeopathic remedy out of the filtrate! And the motivating finding was that although filtrate should not have contained the bacteria, they (according to authors), or at least the effects caused by them, appeared within weeks to it! This is of course impossible in the word of skeptic.

The next reaction of the skeptic is of course that this is fraud or the experimenters are miserable crackpots. Amusingly, one of the miserable crackpots is Nobelist Luc Montagnier, whose research group discovered AIDS virus.

How TGD could explain the findings?

Let us leave the raging skeptics for a moment and sketch possible explanations in TGD framework.

1. Skeptic would argue that the filtration allowed a small portion of infected cells to leak through the filter. Many-sheeted space-time suggests a science fictive variant of this explanation. During filtration part of the infected cells is "dropped" to large space-time sheets and diffused back to the original space-time sheets during the next week. This would explain why the micro-organisms were regenerated within few weeks. Same mechanism could work for ordinary molecules and explain homeopathy. This can be tested: look whether the molecules return back to the diluted solution in the case of a homeopathic remedy.

2. If no cells remain in the filtrate, something really miraculous looking events are required to make possible the regeneration of the effects serving as the presence of cells. This even in the case that DNA fragments remain in the filtrate.

   (a) The minimum option is that the presence of these structures contained only the relevant information about the infecting bacteria and this information coded in terms of frequencies was enough to induce the signatures of the infection as a kind of molecular conditioning. Experimentalists can probably immediately answer whether this can be the case.

   (b) The most radical option is that the infecting bacteria were actually regenerated as experimenters claim! The information about their DNA was in some form present and was transcribed to DNA and/or RNA, which in turn transformed to proteins. Maybe the small fragment of DNA (adhesin) and this information should have been enough to regenerate the DNA of the bacterium and bacterium itself. A test for this hypothesis is whether the mere nanoparticles left from the DNA preparation to the filtrate can induce the regeneration of infecting molecules.

The notion of magnetic body carrying dark matter quantum controlling living matter forms the basic element of TGD inspired model of quantum biology and suggests a more concrete model. The discovery of nanotubes connecting cells with distance up to 300 μ [I40] provides experimental support for the notion.

1. If the matter at given layer of the onion-like structure formed by magnetic bodies has large $\hbar$, one can argue that the layer corresponds to a higher evolutionary level than ordinary matter with longer time scale of memory and planned action. Hence it would not be surprising if the magnetic bodies were able to replicate and use ordinary molecules as kind of sensory receptors

and motor organs. Perhaps the replication of magnetic bodies preceded the replication at DNA level and genetic code is realized already at this more fundamental level somehow. Perhaps the replication of magnetic bodies induces the replication of DNA as I have suggested.

2. The magnetic body of DNA could make DNA a topological quantum computer [K5]. DNA itself would represent the hardware and magnetic bodies would carry the evolving quantum computer programs realized in terms of braidings of magnetic flux tubes. The natural communication and control tool would be cyclotron radiation besides Josephson radiation associated with cell membranes acting as Josephson junctions. Cyclotron frequencies are indeed the only natural frequencies that one can assign to molecules in kHz range. There would be an entire fractal hierarchy of analogs of EEG making possible the communication with and control by magnetic bodies.

3. The values of Planck constant would define a hierarchy of magnetic bodies which corresponds to evolutionary hierarchy and the emergence of a new level would mean jump in evolution. Gel like phases could serve as a correlate for the presence of the magnetic body. The phase transitions changing the value of Planck constant and scale up or down the size of the magnetic flux tubes. They are proposed to serve as a basic control mechanism making possible to understand the properties and the dynamics of the gel phases and how biomolecules can find each other in the thick molecular soup via a phase transition reducing the length of flux tubes connecting the biomolecules in question and thus forcing them to the vicinity of each other.

Consider now how this model could explain the findings.

1. Minimal option is that the flux tubes correspond to "larger space-time sheets" and the infected cells managed to flow into the filtrate along magnetic flux tubes from the filter. This kind of transfer of DNA might be made possible by the recently discovered nanotubes already mentioned.

2. Maybe the radiation resulted as dark photons invisible for ordinary instruments transformed to ordinary photons as the gel phase assignable with the dark matter at magnetic flux tube network associated with the infected cells and corresponding DNA was destroyed in the filtration.

   This is not the only possible guess. A phase conjugate cyclotron radiation with a large value of Planck constant could also allow for the nanostructures in dilute solute to gain metabolic energy by sending negative energy quanta to a system able to receive them. Indeed the presence of ambient radiation was necessary for the emission. Maybe that for sufficiently dilute solute this mechanism allows to the nanostructures to get metabolic energy from the ambient radiation whereas for the gel phase the metabolic needs are not so demanding. In the similar manner bacteria form colonies when metabolically deprived. This sucking of energy might be also part of the mechanism of disease.

3. What could be the magnetic field inducing the kHz radiation as a synchrotron radiation?

   (a) For instance, kHz frequency and its harmonics could correspond to the cyclotron frequencies of proton in magnetic field which field strength slightly above that for Earth's magnetic field (750 Hz frequency corresponds to field strength of B_E, where $B_E = .5$ Gauss, the nominal strength of Earth's magnetic field). A possible problem is that the thickness of the flux tubes would be about cell size for Earth's magnetic field from flux quantization and even larger for dark matter with a large value of Planck constant. Of course, the flux tubes could make themselves thinner temporarily and leak through the pores.

   (b) If the flux tube is assumed to have thickness of order 20-100 nm, the magnetic field for ordinary value of $\hbar$ would be of order .1 Tesla from flux quantization and in the case of DNA the cyclotron frequencies would not depend much on the length of DNA fragment since the it carries a constant charge density. Magnetic field of order .2 Tesla would give cyclotron frequency of order kHZ from the fact that the field strength of .2 Gauss gives

frequency of about .1 Hz. This correspond to a magnetic field with flux tube thickness ~ 125 nm, which happens to be the upper limit for the porosity. Dark magnetic flux tubes with large $\hbar$ are however thicker and the leakage might involve a temporary phase transition to a phase with ordinary value of $\hbar$ reducing the thickness of the flux tube. Perhaps some genes (adhesin) plus corresponding magnetic bodies representing DNA in terms of cyclotron frequencies depending slightly on precise weight of the DNA sequence and thus coding it correspond to the frequency of cyclotron radiation are the sought for nano-structures.

4. While developing a model for homeopathy based on dark matter I ended up with the idea that dark matter consisting of nuclear strings of neutrons and protons with a large value of $\hbar$ and having thus a zoomed up size of nucleon could be involved. The really amazing finding was that nucleons as three quark systems allow to realize vertebrate code in terms of states formed from entangled quarks [L3], [L3] described also in this chapter! One cannot decompose codons to letters as in the case of the ordinary genetic code but codons are analogous to symbols representing entire words in Chinese. The counterparts of DNA, RNA, and amino-acids emerge and genetic code has a concrete meaning as a map between quantum states.

Without any exaggeration this connection between dark hadronic physics and biology has been one of the greatest surprises of my professional life. It suggests that dark matter in macroscopic quantum phase realizes genetic code at the level of nuclear physics and biology only provides one particular (or probably very many as I have proposed) representations of it. If one takes this seriously one can imagine that genetic information is represented by these dark nuclear strings of nanoscopic size and that there exists a mechanism translating the dark nuclei to ordinary DNA and RNA sequences and thus to biological matter. This would explain the claimed regeneration of the infected cells.

5. Genetic code at dark matter level would have far reaching implications. For instance, living matter - or rather, the magnetic bodies controlling it - could purposefully perform genetic engineering. This forces me to spit out another really dirty word, "Lamarckism" ! We have of course learned that mutations are random. The basic objection against Lamarckism is that there is no known mechanism which would transfer the mutations to germ cells. In the homeopathic Universe of TGD the mutations could be however performed first for the dark nucleon sequences. After this these sequences would diffuse to germ cells just like homeopathic remedies do, and after this are translated to DNA or RNA and attach to DNA.

The findings of both Montagnier and Gariaev suggests that also the representation of genetic code in terms of dark photons is involved. How genetic code could be represented in terms of frequencies? The TGD based model of music harmony [L19] [K91] (see http://tinyurl.com/zg3aaj7) relies on the idea that 12-note scale is representable as a closed non-self-intersecting curve (Hamilton's cycle) at icosahedron having 12 vertices. The harmony assignable to a given Hamilton's cycle is characterized in terms of 3-chords assignable to the 20 faces (triangles) of the icosahedron once the 12-note scale is represented as a particular Hamilton's cycle.

Remarkably, the number of amino-acids is also 20! One indeed ends up with a model in which 20+20+20=60 DNA codons are represented by 3-chords for a triplet of harmonies defined by Hamilton's cycles predicting correctly the numbers of DNAs coding for a given amino-acid for vertebrate code. One must however assume that also tetrahedral harmony is present to get 64 DNA codons rather than only 60. TActually two variants of the code are predicted and altogether one obtains the standard 20 amino-acids plus two additional ones identified as Pyl and Sec known to be realized in living matter.

In music realization DNA codons can be represented as 3 dark photons or phonons with appropriate frequency ratios. This representation could explain the findings of Montagnier and Gariaev. There is also a connection with TGD inspired theory of consciousness. Music both expresses and induces emotions. The proposal is that the representation of DNA codons in terms of triplets of sounds or dark photons defines molecular level representation of emotions. There is large number of different harmonies and they could represent different moods.

7.3.2   A Model For Chiral Selection

Chiral selection of bio-molecules is one of the basic mysteries of biology and it is interesting to see whether the existing bits of data combined with vision about quantum TGD could help to build a coherent picture about the situation. Let us first try to identify the most important pieces of the puzzle.

1. Chiral selection requires parity breaking in the scale of biomolecules. Standard model predicts parity breaking interactions but the effects are extremely small above intermediate boson length scale which is by a factor 10^{-7} shorter than atomic length scale. The proposed solution of the problem is that dark variants of intermediate gauge bosons are in question so that the Compton lengths of intermediate gauge bosons are scaled up by a factor $r = \hbar/\hbar_0$. Below the dark Compton length weak gauge bosons would be effectively massless and above it possess ordinary masses. Large parity breaking effects induced by dark intermediate gauge bosons would be possible.

2. For instance, for $r = 2^{44}$ for which EEG photons have energies just above thermal threshold at room temperature, the effective p-adic length scale would correspond to $L(k)$, $k = 89 + 44 = 133$ of about.2 Angstrom. This scale in turn would scale up to $L(133 + 44 = 177)$. Secondary p-adic length scale assignable to $k = 89$ which is important in zero energy ontology would correspond to $k = 2 \times 89 = 178$ which corresponds to about $L(178) \simeq 100$ μm, the length scale assignable to large cells and the thickness of water layers in the experiment of Pollack.

3. Parity breaking interaction is associated with spin and the interaction energy of form $ks \cdot E_Z$, where s is the spin of particle and E_Z is Z^0 electric field. Classical induced gauge fields are very strongly correlated in TGD since they are expressible in terms of four CP_2 coordinates and their gradients. Hence classical electromagnetic field E is in the generic case accompanied by classical Z^0 field $E_Z = aE$. This means that if there is classical electromagnetic field and charge density at the dark space-time sheet, large parity breaking effect is possible at the level of spin. The induced Z^0 electric field could force the spins to become parallel and in this manner induce also magnetization.

The crucial finding about which I learned three years ago is that L glutamate is more stable than R glutamate in water and that heavy water does not induce this effect [I146]. This suggests a connection with Pollack-Zheng effect [D72]. Heavy water nuclei have vanishing spin whereas hydrogen nuclei have spin 1/2 so that H_2 in water molecules can be in spin singlet or triplet states (para and orto configurations). Could the nuclear spin of water molecules somehow induce parity breaking and the magnetic interaction distinguishing between these molecules?

1. Suppose that bio-molecules in question have magnetic moment and water carries magnetic field, most naturally at dark magnetic flux tubes. The parity breaking interaction energy $-p \cdot E$ with dark electric field remains invariant under reflection and rotation of π changing the orientation of the mirror image of the molecule with respect to electric field. The interaction energy with magnetic field however changes its sign since magnetic moment is not affected by the reflection but changes direction under rotation. The angular momentum of the molecule responsible for the magnetic moment can of course change sign but since the transformation involves acts on angular momenta only, it is not a symmetry of entire system. Indeed, if there is interaction between angular momentum degrees of freedom and geometric degrees of freedom the magnetic interaction energy for the mirror image is different. Suppose that the breaking of reflection symmetry induced by the chirality of the molecule induces internal electric field E_{int}. The parity breaking interaction energy $ks \cdot E_{int}$ would indeed break the symmetry in the transformation changing the directions of angular momenta and spins.

2. It deserves to be emphasize that the parity breaking of the molecule itself would induce the symmetry breaking if molecule possesses dark magnetic body. One can actually imagine a cascade of parity breakings proceeding from shorter to longer length scales in this manner.

3. The mechanism creating electric field could be the charging of water, perhaps by the Pollack-Zheng mechanism and having in TGD framework an interpretation as a basic mechanism

storing the energy of sunlight to metabolic energy (kicking of electrons and/or protons to a smaller space-time sheet so that oppositely charge space-time sheets emerge as a consequence). A direct connection with metabolism would be admittedly a highly satisfactory feature of the mechanism.

4. Parity breaking energy $ks \cdot E$ for say dark protons assignable to hydrogen nuclei of biomolecules in the internal electric field of the molecule or dark protons of water molecules in the electric field induced by Pollack-Zheng effect [D72] does not change sign under the reflection of the molecule so that spin polarization independent of chirality could result form both water molecules in crystal like phase and for bio-molecules possessing dark protons (and dark hydrogen atoms). This could in turn serve as a seed for magnetization essential for the existence of dark magnetic flux tubes.

If water is replaced with heavy water there is no difference between L and R. What distinction H and D could explain this difference?

1. The basic difference between water and heavy water nuclei is that for water nucleus is just proton having spin 1/2 so that H_2 in water molecule can be in spin triplet and singlet states. Fractions of the two states are 3/4 and 1/4 in the absence of external magnetic field.

2. On the other hand, in atto-second time scale (corresponding length scale is 3 Angstroms) water is known to behave effectively as $H_{1.5}O$. A possible explanation is that 1/4: th of H nuclei/atoms are effectively dark having large Planck constant. The dark protons cannot correspond to H_2 in spin singlet state since the interaction energy $ks \cdot E$ would be small in this case. Dark spin triplet states of H_2 could however induce parity breaking in water and make crystal like water phase both electret and magnet. If the spin $s_z = 1$ with negative interaction energy with E becomes dark then 1/4 of hydrogen atoms would be dark and $H_{1.5}O$ formula would hold true. For D_2O this mechanism would not work.

3. The model for homeopathy led to the idea that dark nuclei consisting of scale up variants of nucleons possibly having size of order atomic length scale could be crucial for understanding living matter. The states of nucleons correspond naturally to those DNA, RNA, and aminocids and vertebrate genetic code emerges naturally with DNA code word replaced with 3 quark state with entanglement between the quarks representing the information. Could it be that dark protons of water combine to form dark nuclei providing a fundamental representation of the genetic code and could the spin of protons induce electro-weak chiral symmetry breaking. Also now this mechanism fails for D_2O.

7.3.3 Burning Water And Photosynthesis

For a physicist liberated from the blind belief in reductionism, biology transforms to a single gigantic anomaly about which recent day physics cannot say much. During years I have constructed several models for these anomalies helping to develop a more detailed view about how the new physics predicted by quantum TGD could allow to understand biology and consciousness.

The basic problem is of course the absence of systematic experimentation so that it is possible to imagine many new physics scenarios. For this reason the article series of Mae-Wan Ho [D64, D62, D60, D63] in ISIS was a very pleasant surprise, and already now has helped considerably in the attempts to develop the ideas further.

The first article "Water electric" [D64] told about the formation of exclusion zones around hydrophilic surfaces, typically gels in the experiments considered [D72]. The zones were in potential of about 100 meV with respect to surroundings (same order of magnitude as membrane potential) and had thickness ranging to hundreds of micrometers (the size of a large cell): the standard physics would suggests only few molecular layers instead of millions. Sunlight induced the effect. This finding allow to develop TGD based vision about how proto cells emerged and also the model for chiral selection in living matter by combining the finding with the anomalies of water about which I had learned earlier.

The article "Can water burn?" [D60] tells about the discovery of John Kanzius - a retired broadcast engineer and inventor. Kanzius found that water literally burns if subjected to a radio

frequency radiation at frequency of 13.56 MHz [D1]. The mystery is of course how so low frequency can induce burning. The article "The body does burn water" [D63] notices that plant cells burn water routinely in photosynthesis and that also animal cells burn water but the purpose is now to generate hydrogen peroxide which kills bacteria (some readers might recall from childhood how hydrogen peroxide was used to sterilize wounds!). Hence the understanding of how water burns is very relevant for the understanding of photosynthesis and even workings of the immune system.

Living matter burns water routinely

Photosynthesis burns water by decomposing water to hydrogen and oxygen and liberating oxygen. Oxygen from CO_2 in atmosphere combines with the oxygen of H_2O to form O_2 molecules whereas H from H_2O combines with carbon to form hydrocarbons serving as energy sources for animals which in turn produce CO_2. This process is fundamental for aerobic life. There is also a simpler variant of photosynthesis in which oxygen is not produced and applied by an-aerobic life forms. The article "Living with Oxygen" by Mae-Wan Ho gives a nice overall view about the role of oxygen [D61]. As a matter fact, also animals burn water but they do this to produce hydrogen peroxide H_2O_2 which kills very effectively bacteria.

Burning of water has been studied as a potential solution for how to utilize the solar energy to produce hydrogen serving as a natural fuel [D62]. The reaction $O_2 + H_2 \rightarrow 2H_2O$ occurs spontaneously and liberates energy of about 1.23 eV. The reverse process $2H_2 \rightarrow H_2O_2 + H_2$ in the presence of sunlight means burning of water, and could provide the manner to store solar energy. The basic reaction $2H_2O + 4h\nu \leftrightarrow H_2O_2 + H_2$ stores the energy of four photons. What really happens in this process is far from being completely understood. Quite generally, the mechanisms making possible extreme efficiency of bio-catalysis remain poorly understood. Here new physics might be involved. I have discussed models for photosynthesis and $ADP \leftrightarrow ATP$ process involved with the utilization of the biochemical energy already earlier [K57].

How water could burn in TGD Universe?

The new results could help to develop a more detailed model about what happens in photosynthesis. The simplest TGD inspired sketch for what might happen in the burning of water goes as follows.

1. Assume that 1/4 of water molecules are partially dark (in sense of nonstandard value of Planck constant) or at least at larger space-time sheets in atto-second scale [D58, D55, D68, D36]. This would explain the $H_{1.5}O$ formula explaining the results of neutron diffraction and electron scattering.

2. The question is what this exotic fraction of water precisely is. The models for water electret, exclusion zones and chiral selection lead to concrete ideas about this. Electrons assignable to the H atoms of (partially) dark H_2O reside at space-time sheet $k_e = 151$ (this p-adic length scale corresponds to 10 nm, the thickness of cell membrane). At least the hydrogen atom for this fraction of water molecules is exotic and findings from neutron and electron scattering suggest that both proton and electron are at non-standard space-time sheets but not necessarily at the same space-time sheet. The model for the burning requires that electron and proton are at different space-time sheets in the initial situation.

3. Suppose all four electrons are kicked to the space-time sheet of protons of the exotic hydrogen atoms labeled by k_p. This requires the energy $E_\gamma = (1 - 2^{-n})E_0(k_p)$ (the formula involves idealizations). At this space-time sheet protons and electrons are assumed to combine spontaneously to form two H_2 atoms. Oxygen atoms in turn are assumed to combine spontaneously to form O_2.

4. For $k_f = 148$ and $n = 3$ minimum energy needed would be $4E_\gamma = 4 \times .4 = 1.6$ eV. For $k_p = 149$ (thickness of lipid layer) and $n = 2$ one would have $4E_\gamma = 4 \times .3462 = 1.385$ eV whereas $H_2O_2 + H_2 \rightarrow 2H_2O$ liberates energy 1.23 eV. Therefore the model in which electrons are at cell membrane space-time sheet and protons at the space-time sheet assignable to single lipid layer of cell membrane suggests itself. This would also mean that the basic length scales of cell are already present in the structure of water. Notice that there is no need to assume that Planck constant differs from its standard value.

There is no need to add, that the model is an unashamed oversimplification of the reality. It might however catch the core mechanism of photosynthesis.

Burning of salt water induced by RF radiation

Engineer John Kanzius has made a strange discovery [D1]: salt water in the test tube radiated by radio waves at harmonics of a frequency f=13.56 MHz burns. Temperatures about 1500 K, which correspond to.15 eV energy have been reported. One can irradiate also hand but nothing happens. The original discovery of Kanzius was the finding that radio waves could be used to cure cancer by destroying the cancer cells. The proposal is that this effect might provide new energy source by liberating chemical energy in an exceptionally effective manner. The power is about 200 W so that the power used could explain the effect if it is absorbed in resonance like manner by salt water.

Mae-Wan Ho's article "Can water Burn?" [D60] provides new information about burning salt water [D1], in particular reports that the experiments have been replicated. The water is irradiated using polarized radio frequency light at frequency 13.56 MHz. The energy of radio frequency quantum is $E_{rf} = .561 \times 10^{-7}$ eV and provides only a minor fraction $E_{rf}/E = .436 \times 10^{-7}$ of the needed energy which is $E = 1.23$ eV for single $2H_2O \rightarrow H_2O_2 + H_2$ event. The structure of water has been found to change, in particular something happens to O-H bonds. The Raman spectrum of the water has changed in the energy range $[0.37, 0.43]$ eV. Recall that the range of metabolic energy quanta $E(k,n) = (1 - 2^{-n})E_0(k)$ varies for electron in the range $[.35, .46]$ eV in the model for the formation of exclusion zone induced by light. Therefore the photons assigned to changes in Raman spectrum might be associated with the transfer of electrons between space-time sheets.

The energies of photons involved are very small, multiples of 5.6×10^{-8} eV and their effect should be very small since it is difficult to imagine what resonant molecular transition could cause the effect. This leads to the question whether the radio wave beam could contain a considerable fraction of dark photons for which Planck constant is larger so that the energy of photons is much larger. The underlying mechanism would be phase transition of dark photons with large Planck constant to ordinary photons with shorter wavelength coupling resonantly to some molecular degrees of freedom and inducing the heating. Microwave oven of course comes in mind immediately.

As I made this proposal, I did not realize the connection with photosynthesis and actual burning of water. The recent experimental findings suggest that dark radio frequency photons transform to photons inducing splitting of water as in photosynthesis so that one should have $r = \hbar/\hbar_0 = E_{rf}/4E$. One could say that large number of radio wave photons combine to form a single bundle of photons forming a structure analogous to what mathematician calls covering space. In the burning event the dark photon would transform to ordinary photon with the same energy. This process would thus transform low energy photons to high energy protons with the ratio $r = \hbar/\hbar_0$.

Therefore the mechanism for the burning of water in the experiment of Kanzius could be a simple modification of the mechanism behind burning of water in photosynthesis.

1. Some fraction of dark radio frequency photons are dark or are transformed to dark photons in water and have energies around the energy needed to kick electrons to smaller space-time sheets .4 eV. After this they are transformed to ordinary photons and induce the above process. Their in-elastic scattering from molecules (that is Raman scattering) explains the observation of Raman scattered photons. For a fixed value of $\hbar$ the process would occur in resonant manner since only few metabolic quanta are allowed.

2. How dark radio frequency photons could be present or could be produced in water? Cyclotron radiation assignable to say electrons in magnetic field comes in mind. If the cyclotron radiation is associated with electrons it requires a magnetic field of 4.8 Gauss the cyclotron frequency is 13.56 MHz. This is roughly ten times the nominal value $B_E = .5$ Gauss of the Earth's magnetic field and 24 times the value of dark magnetic field $B_d = .4B_E = .2$ Gauss needed to explain the effects of ELF em fields on vertebrate brain. Maybe dark matter at flux tubes of Earth's magnetic field with Planck constant equal to $\hbar/\hbar_0 = \frac{1}{4}\frac{E}{E_{rf}}$ transforms radio frequency photons to dark photons or induces resonantly the generation of cyclotron photons, which in turn leak out from magnetic flux tubes and form ordinary photons inducing the burning of water. $E_\gamma = .4$ eV would give $\hbar/\hbar_0 == 1.063 \times 2^{21}$ and $E_\gamma = .36$ eV would give $\hbar/\hbar_0 = .920 \times 2^{21}$.

3. Magnetic fields of magnitude.2 Gauss are in central role in TGD based model of living matter and there are excellent reasons to expect that this mechanism could be involved also with processes involved with living matter. There is indeed evidence for this. The experiments of Gariaev demonstrated that the irradiation of DNA with 2 eV laser photons (which correspond to one particular metabolic energy quantum) induced generation of radio wave photons having unexpected effects on living matter (enhanced metabolic activity) [I55], and that even a realization of genetic code in terms of the time variation of polarization direction could be involved. TGD based model [K23, K116] identifies radio-wave photons as dark photons with same energy as possessed by incoming visible photons so that a transformation of ordinary photons to dark photons would have been in question. The model assumed hierarchy of values of magnetic fields in accordance with the idea about onion like structure of the magnetic body.

There are several questions to be answered.

1. Is there some trivial explanation for why salt must be present or is new physics involved also here. What comes in mind are Cooper pairs dark Na^+ ions (or their exotic counterparts which are bosons) carrying Josephson currents through the cell membrane in the model of the cell membrane as a Josephson junction which is almost vacuum extremal of Kähler action. In the experimental arrangement leading to the generation of exclusion zones the pH of water was important control factor, and it might be that the presence of salt has an analogous role to that of protons.

2. Does this effect occur also for solutions of other molecules and other solutes than water? This can be tested since the rotational spectra are readily calculable from data which can be found at net.

3. Are the radio wave photons dark or does water - which is very special kind of liquid - induce the transformation of ordinary radio wave photons to dark photons by fusing $r = \hbar/\hbar_0$ radio wave massless extremals (MEs) to single ME. Does this transformation occur for all frequencies? This kind of transformation might play a key role in transforming ordinary EEG photons to dark photons and partially explain the special role of water in living systems.

4. Why the radiation does not induce spontaneous combustion of living matter which contains salt. And why cancer cells seem to burn: is salt concentration higher inside them? As a matter fact, there are reports about [D7]. One might hope that there is a mechanism inhibiting this since otherwise military would be soon developing new horror weapons unless it is doing this already now. Is it that most of salt is ionized to Na^+ and Cl^- ions so that spontaneous combustion can be avoided? And how this relates to the sensation of spontaneous burning [D6] - a very painful sensation that some part of body is burning?

5. Is the energy heating solely due to rotational excitations? It might be that also a "dropping" of ions to larger space-time sheets is induced by the process and liberates zero point kinetic energy. The dropping of proton from k=137 (k=139) atomic space-time sheet liberates about.5 eV (0.125 eV). The measured temperature corresponds to the energy.15 eV. This dropping is an essential element in the ealier of remote metabolism and provides universal metabolic energy quanta. It is also involved with TGD based models of "free energy" phenomena. No perpetuum mobile is predicted since there must be a mechanism driving the dropped ions back to the original space-time sheets.

In many-sheeted space-time particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries of space-time sheet of a given system. Also p-adic phase transition increasing the size of the space-time sheet could take place and the liberated energy would correspond to the reduction of zero point kinetic energy. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant h_{eff} so that cyclotron energy would be liberated.

6. The electrolysis of water and also cavitation produces what is known as Brown's gas which should consist of water vapour and there might be a connection to the burning of salt water. The properties of Brown's gas [H9] however do not support this interpretation: for instance,

Brown's gas has temperature of about 130 C but is able to melt metals so that some un-known mechanism liberating energy must be involved explaining also the claims about over-unity energy production in water splitting using electrolysis. TGD inspired model for Brown's gas [K58] suggests that activated water and Brown's gas correspond to same phase involving polymer sequences formed from exotic water molecules for which one hydrogen nucleus is dark and defining the analogs of basic biopolymers. The bond binding protons to a polymer like sequence would serve as the counterpart of covalent bond.

One also ends up with a more detailed TGD inspired view about basic mechanism of metabolism in living matter predicting a tight correlation between p-adic length scale hypothesis and hierarchy of Planck constants. The model differs in some aspects from the rough models considered hitherto assuming that metabolic energy is liberated as zero point kinetic energy when particle drops to a larger space-time sheet or as cyclotron energy when cyclotron quantum number decreases. Now a phase transition increasing the p-adic length scale of the space-time surface would liberate either kinetic energy of cyclotron energy. Quantum numbers would not change: rather, t the scale appearing as a parameter in the expression of kinetic or cyclotron energy would change adiabatically and in this manner guarantee coherence. Also a phase transition in which the changes of scale due to a reduction of Planck constant and increase of the p-adic length scale compensate each other liberate metabolic energy.

Recall that one of the empirical motivations for the hierarchy of Planck constants came from the observed quantum like effects of ELF em fields at EEG frequencies on vertebrate brain and also from the correlation of EEG with brain function and contents of consciousness difficult to understand since the energies of EEG photons are ridiculously small and should be masked by thermal noise.

Free radicals, expanding Earth, water memory, and Cambrian revolution

The title is intentionally chosen to involve notions which one would expect to have absolutely nothing in common. The purpose is to show that this expectation might be wrong. Consider first the free radical theory [I13]. The theory states that free radical produced in mitochondria are responsible for the ageing since they are highly reactive and cause damage for the DNA. One can however wonder what is the mechanism causing the generation of the free radicals.

A TGD based justification for the free radical theory came as unexpected application of the quantum model for how metabolic batteries are loaded in many-sheeted space-time. The kicking of electrons, protons, or ions to smaller space-time sheet loads metabolic batteries in TGD Universe. A more refined model is based on a phase transition which increases p-adic prime and decreases the value of h_{eff} so that the two length scale changes compensate each other. The zero point kinetic energy or cyclotron energy associated with the magnetic flux tube is reduced in the process and liberate. Therefore this kind of process could liberate metabolic energy.

These processes could occur all the time in ADP$\leftrightarrow$ATP "Karma's" cycle. In this case the transfer or protons through the cell membrane would induce the change of Planck constant and therefore a liberation of metabolic energy stored in roughly the same manner as it is stored in battery. Now however the liberated energy is sum of electrostatic energy and difference of cyclotron energies replacing the difference of chemcical potentials in the case of ordinary battery. The quantitative model for the burning of water producing hydrogen peroxide and hydrogen (this process could provide a mechanism of storing solar energy by a mechanism analogous to photosynthesis) would also rely on this mechanism.

Burning water, photo synthesis, and water memory

The burning of water, photons synthesis and water memory are closely interrelated phenomena in TGD Universe. Recall first what was observed in the experiments carried out by the group led by Luc Montagnie.

1. What was done was filtration of human cells infected by bacteria in sterilization purpose to eliminate the infected cells. Human cells were added to the filtrate. Rather magically, the infection returned to the filtrate within few weeks. Something having size of order of

nanoscale leaked through. It was also found that when the filtrate was diluted by water to produce an analog of homeopathic remedy, it produced at multiples of kHz if the dilution factor was in the range $10^{-7} - 10^{-12}$.

2. The second discovery was that if you have two bottles containing a solute of nanostructures such that for the first one dilution factor is small and for the second in the critical range so that it radiates at kHz frequencies. What was found that in the final situation neither radiates but only if the dilutions correspond to the same bacterial species! I proposed two interpretations. The first one was that the nanoscale systems in the highly diluted system are starving and gain metabolic energy by sending negative energy photons to the low dilution system and this makes them possible to replicate and achieve higher dilution after which the process stops.

3. One of the most fascinating possibilities suggested by the discovery is that the nanoscale structures identified as certain gene of the bacteria plus possibly something else (the magnetic body of gene in TGD context) might have been able to regenerate the bacteria themselves! This would require a non-chemical representation of genetic code and its translation to DNA or RNA. For about year ago I indeed discovered a realization of genetic code in terms of dark nuclei with states of nucleons representing the code words [L3], [L3].

These findings allow a more detailed interpretation of the findings of the experiments of the group of Luc Montagnie.

1. The mysterious burning of water induced by radio waves in GHz range and interpreted in terms of a decomposition of water molecules to hydrogen peroxide and hydrogen: $2H_2 \rightarrow H_2O_2 + H_2$ is closely related to the splitting of water to hydrogen and oxygen occurs also in photosynthesis. The interpretation was that radio waves are resonantly transformed to dark photons with same frequency but with very large value of Planck constant and hence of energy followed by a transformation to ordinary IR photons with much higher frequency but same energy energy around.4 eV [K53, K95]. The finding that Raman scattering (non-elastic scattering of photons on molecules) around this energy occurs in the burning water supports this view. The natural guess is that also in the recent case something similar occurs.

2. This kind of frequency scaling is one of the basic mechanisms of water memory as I learned for the first time from the lecture of Cyril Smith in CASYS conference many years ago. One of the basic findings was that there is an unknown mechanism transforming low frequencies to high ones and vice versa. The low frequencies are scaled up by a factor which has a preferred value $r \simeq 2 \times 10^{11}$ interpreted in TGD framework as the ratio of the dark matter Planck constant to the ordinary one. I christened this correlation as a scaling law of homeopathy.

3. It is interesting to apply the law to kHz frequency. In this case the law would give frequency $f = 2 \times 10^{14} >$ Hz. The corresponding energy is.826 eV, which is essentially twice the energy quantum associated with burning water and thus has interpretation as a p-adically scaled up frequency (by one octave). Interestingly, Mae-Wan Ho states in [D61] that *"to use water as electron-donor, and hence to produce oxygen, requires the creation of the chlorophyll-a in cyanobacteria and green plants that can be boosted to a higher electrochemical potential of 0.82 V"*. Hence.83 eV is very near to a metabolically interesting energy.

4. This finding supports the view that kHz radiation produced by nano-structures corresponds to dark phase conjugate photons with energy equal to a metabolic energy quantum. The interpretation would be that the unidentified nanoscale systems in the highly diluted system are starving and get metabolic energy by sending negative energy quanta in the hope that there are metabolic energy reservoirs around able to absorb them. If bio-photons are Bose Einstein condensates of dark cyclotron photons at the flux tubes of magnetic body acting like population reversed lasers, they could serve as metabolic energy reservoir as suggested in on basis of the discovery described by Mae-Wan Ho in [D64].

5. A continual fight for metabolic resources is raging everywhere in Nature, presumably also at the monocellular level. It would not be surprising if harmful bacteria would try to steal the

metabolic energy of other organisms stored (say) as bio-photons by sending phase conjugate light to the bio-photon resources of multicellular organisms. Nor it would be surprising if living organisms would have developed ways to prevent this. The fine tuning of the metabolic frequencies so that only the members of the same species can share the energy could guarantee this. Also password like protocols might have developed and either or both of them might be involved.

In the two-bottle experiments the nanoscale systems in the highly diluted system would gain metabolic energy by sending negative energy photons received by the low dilution system. The gain of metabolic energy would make possible for the nanosystems to replicate and achieve higher dilution after which the process would stop as was indeed observed. That this took place only for the bacteria of same species supports the interpretation that frequency tuning or password mechanism was involved. This metabolic mechanism (quantum credit card as I have called it) could be a completely general mechanism energy sharing mechanism for cells of the same multicellular organism and perhaps even same species in TGD Universe.

7.4 A Model For The Effective Electronic Super-Conductivity In Axons

Also the following model for axonal electronic super-conductivity was constructed before the progress induced by the model of DNA as TQC and the inspiration coming from the model of nerve pulse by Danish researches [J84] and is not completely consistent with the new model. I however decided to keep the text because it reflects the development of ideas and with a reasonable amount of work could be modified to the new situation.

Hafedh Abdelmelek and collaborators [J34] have found evidence for effective super-conductivity in the sciatic nerves of both endotherms (rabbit) and poikilotherms (frog). The basic finding is that the resistance of the sciatic nerve is reduced by a factor of about ten below a critical temperature at the lower edge of the range of the physiological temperatures. The reduction of the temperature occurs inside a narrow temperature range ΔT, $\Delta T/T_c \sim .04$. This suggests effective super-conductivity. Furthermore, the critical temperature T_c for the breaking of the effective super-conductivity raises from 240 K to 300 K in the transition from poikilotherms (say frog) to endotherms (say rabbit).

These findings seem to be consistent with the following view.

1. Nerve pulse generation involves a mechanism inducing a flow of ions between axonal interior and exterior and induces at the same time the breaking of super-conductivity [K95] . At too low temperatures nerve pulses cannot be generated because the breaking of the super-conductivity is not possible. Therefore the critical temperature must be below the range of physiological temperatures and explains the difference between poikiloterms and endotherms.

2. In myelin sheathed regions the breaking of the effective super conductivity does not occur or the critical temperature is higher and the signal carried by the nerve pulse is transformed to an effective or genuine supra current. A small pulse like perturbation of the membrane potential could propagate still.

3. Poikilotherms can survive only if nerve pulse conduction is possible down to about 240 K which represents lower bound for the temperature of environment. Endotherms can keep the body temperature above 300 K and so that T_c can be as high as 300 K. This is good for survival purposes since high T_c minimizes ohmic losses related to nerve pulse conduction.

The recent model for nerve pulse generation favors somewhat different view. The melting temperatures T_m of the axon and microtubular surface and quantum critical temperature T_c of high T_c super-conductivity are the critical parameters. The generation of the nerve pulse is possible only if T is slightly above T_m. T_m can vary in a wide range and can be controlled genetically. Same could be true for T_c since external perturbations amplified by quantum criticality are expected to affect it. This would explain different values of T_c for poikilotherms and endotherms. The critical temperature for super-conductivity would pose only an upper bound for the temperatures

at which organisms can survive whereas quantum criticality of various membranes would constrain this temperature to a narrow range.

7.4.1 Many-Sheeted Space-Time And Connection Between Thermal De-Broglie Wavelength And Size Of The Space-Time Sheet

The concept many-sheeted space-time is needed to understand super-conductivity and breaking of super-conductivity. Parallel space-time sheets with distance about 10^4 Planck lengths form a hierarchy. Each material object (..., atom, molecule, ..., cell, ...) corresponds to this kind of space-time sheet. The p-adic primes $p \simeq 2^k$, k prime or power of prime, characterize the size scales of the space-time sheets in the hierarchy. The p-adic length scale $L(k)$ can be expressed in terms of cell membrane thickness as

$$L(k) = 2^{(k-151)/2} \times L(151) \ , \tag{7.4.1}$$

where the p-adic length scale $L(151)$ and all p-adic length scales above electron length scale $L(127)$ were identified erratically in all writings about TGD before 2014. This deserves some comments.

1. The wrong identification was $L(151) \simeq 10$ nm implying wrong identification of other scales above $L(127)$ since I have calculated them by scaling $L(151)$ by an appropriate power of two. What I have denoted by $L(151)$ is actually obtained by scaling the Compton length $L_e(127) = \hbar/m_e$ by $2^{(151-127)/2}$ and therefore electrons Compton scale if it would correspond to $k = 151$. Since the mass of electron from p-adic mass calculations is given by $m_e = \sqrt{5 + X}\hbar/L(127)$, the correct identification of $L(151)$ would be

$$L(151) = 2^{(151-127)/2}L(127) = 2^{(151-127)/2}L_e(151)/\sqrt{5 + X} = 10/\sqrt{5 + X} \ \ nm \ , \ \ 0 \leq X \leq 1 \ .$$

   Here X denotes the unknown second order contribution of form $X = n/M_{127}$, n integer, to the electron mass, and in the first approximation one can take $X = 0$ - the approximation is excellent unless n is very large. In the sequel I will try to use the shorthand $L_e(k) = \sqrt{5}L(k)$ but cannot guarantee that the subscript "e" is always present when needed: it is rather difficult to identify all places where the earlier erratic definition appears. I can only apologise for possible confusions.

2. This mistake has no fatal consequences for TGD inspired quantum biology. Its detection however provides a further support for the speculated central role of electron in living matter. Since the scales obtained by scaling the electron Compton scale seem to be important biologically (scaled up Comton scale $\sqrt{5}L(151)$ corresponds to cell membrane thickness), the conclusion is that electrons - or perhaps their Cooper pairs - play a fundamental role in living matter. The correct value of $L(151)$ is $L(151) = 4.5$ nm, which is slightly below the p-adic length scale $L_e(149) = 5$ nm assigned with the lipid layer of cell membrane.

3. I have also assigned to electron the time scale $T = .1$ seconds defining a fundamental biorhythm as a secondary p-adic time scale $T_2(127) = \sqrt{M_{127}}T(127)$. The correct assignment of $T = .1$ seconds is as the secondary Compton time $T_{2,e}(127) = \sqrt{M_{127}}T_e(127)$ of electron: secondary p-adic time scale is $T_2(127) = \sqrt{M_{127}}T(127)$ and corresponds to $T_{2,e}(127)/\sqrt{5} = .045$ seconds and to $f(127) = 22.4$ Hz.

These are so called primary p-adic length scales but there are also n-ary p-adic length scales related by a scaling of power of $\sqrt{p}$ to the primary p-adic length scale.

The characteristic temperature scale for particles of mass M in a thermal equilibrium at the space-time sheet characterized by $L(k)$ is given in terms of the zero point kinetic energy associated with the space-time sheet

$$T(k) \ \ = \ \ n \times E_0(k) = n \times n_1 \times \frac{\pi^2}{2ML^2(k)} \ , \tag{7.4.2}$$

where n and n_1 are numerical constants not far from unity (for convenience the units $k_B = 1$, $\hbar = 1$, $c = 1$ are used). $T(k)$ decreases very rapidly as a function of the p-adic length scale $L(k)$. This equation relates the p-adic prime of space-time sheet to T and M of particles present in the sheets forming join along boundaries condensate. Of course, the size L of space-time sheet characterized by k can vary in the range $[L(k), L(k_>)]$ and $T \propto 1/L^2$ is an attractive guess for the dependence of the temperature on the size of the space-time sheet. One can interpret $T(k)$ as a critical temperature at which the p-adic prime characterizing the space-time sheet changes.

7.4.2   Magnetic Flux Tubes As Effective Super-Conductors And Breaking Of Super-Conductivity

The model for bio-superconductivity and its breaking relies on the following picture.

1. Magnetic flux tubes of Earth's magnetic field (in particular) characterized by $k = 169$ and having a minimal thickness about 5 μm correspond to tubular space-time sheets. The magnetic flux tubes of endogenous magnetic field $B = .2$ with $n = 5$ characterizing the value of the scaled up Planck constant $\hbar = n\hbar_0$ [K46] and the unit $n h_0$ of magnetic field magnetic flux and $k = 169$ characterizing the p-adic length scale define second option consistent with the identification of 15 Hz as cyclotron frequency of Ca^{+2}. In this case the value of magnetic flux is $2h_5$ and the scaled down magnetic field $B_{end}/2$ required by the sleep time EEG would correspond to single flux quantum. Flux tubes would have thickness of about 25 μm corresponding to a size of a large neuron.

   In the absence of both larger and smaller space-time sheets, the flux quanta can act as 1-D super-conductors since cyclotron energy scale, which by the quantization of the magnetic flux behaves also as $1/L^2(k)$, is larger than de Broglie temperature for sufficiently high values n of the magnetic flux (implying thicker flux tube). More generally, one can consider the possibility of a hierarchy of magnetic flux tubes inside magnetic flux tubes corresponding to the sequence $k = 167, 163, ...$ as especially interesting candidate since $k = 151, 157, 163, 167$ define Gaussian Mersennes $(1 + i)^k - 1$. Each of these flux tubes can be a super-conductor. Bio-super-conductivity is assumed to be due to this mechanism. Of course, only space-time sheets corresponding to only some of these p-adic length scales could be present and this would be crucial as far as super-conductivity and its breaking is considered. The study of the effects of external magnetic fields on the axonal conductivity might provide valuable information about the role of magnetic fields.

2. Super-conductivity can be broken by a temporal leakage of the Cooper pairs to larger space-time sheets if present. These Cooper pairs are kicked back by thermal photons. System is an effective super-conductor in the sense that Cooper pairs are not destroyed in the breaking of super-conductivity and an effective ohmic conductor in the sense that dissipation is present. Super-conductivity can be also broken by thermal kicking of the Cooper pairs to smaller space-time sheets. In this case there is however a restriction posed by the fact that the zero point kinetic energy of the particle increases from $E_0(k)$ to $E_0(k_<)$, where $k_<$ ($k_>$) is the largest (smallest) the prime smaller (larger) than k. Thermal energy is needed to achieve this. For the leakage to occur, one must have

$$ T > nE_0(k) \;\; = \;\; T(k) \;\; . \tag{7.4.3} $$

   Some numerical constant n is involved here. Note that the temperature at super-conducting space-time sheets is much lower than the critical temperature and the temperature at atomic space-time sheets.

3. The prediction is that the conductivity decreases in a stepwise manner at temperatures $T = T(k)$ as the temperature increases, and that the smallest value of k for current carrying space-time sheets gradually decreases as $k = 169 \rightarrow 167 \rightarrow 163 \rightarrow 157 \rightarrow 151 \rightarrow ....$ The behavior of the conductivity in the sciatic nerve seems to represent one particular step of this kind. The primes $k = 167, 163, 157, 151$ are expected to be especially important in living

matter since they corresponds to the so called Gaussian Mersennes and p-adic length scales in the range 10 nm-2.56 μm [K25, K26].

4. For a space-time sheet having $k = k_0$, the leakage of supra-current is induced by the formation of flux tubes between $k = k_0$ space-time sheets and $k \geq k_0$ space-time sheets. The leakage to the smaller space-time sheets can be also induced by radiation with frequency corresponding to the increment of the zero point kinetic energy and the transversal electric field involved with radiation can be regarded as inducing the force driving the particles to smaller space-time sheets or back.

5. The strange findings indicating that DNA can behave like a super-conductor [I59], an ohmic conductor [I86], or an insulator could be perhaps understood in terms of the local architecture of the many-sheeted space-time. If only atomic space-time sheet is present, DNA would behave as insulator. If larger space-time sheets are present DNA behaves as an effective ohmic conductor in the sense that dissipative effects are present. If only single larger space-time sheet is present, super-conductivity is possible so that the manufacturing of super-conductors should reduce to space-time engineering.

7.4.3 Quantitative Model For The Breaking Of Super-Conductivity

The dropping (or leakage) of electronic Cooper pairs from $k = k_0$ (say $k_0 = 151$ corresponding to cell membrane thickness) space-time sheet to larger space-time sheets possibly present and followed by a thermal kicking back to $k = k_0$ space-time sheet is a good candidate for the mechanism causing the breaking of magnetic super-conductivity.

The conductivity as a function $\sigma(k)$ of the p-adic length scale $L(k)$ should characterize the mechanism quantitatively. If the thermal energy $E_{th} = T$ satisfies the condition

$$E_0(k) - E(k_>) < T < E_0(k_<) - E(k) \ ,$$
$$E_0(k) = n_1 \times \frac{\pi^2}{4m_e L^2(k)} \ , \tag{7.4.4}$$

one can say that the space-time sheet k is the effective carrier of the current.

The mechanism predicts that the increase of the temperature is accompanied by a sequence of phase transitions in which the value of k characterizing the effective carrier of the current decreases in a stepwise manner: $k = 169 \to 167 \to 163 \to 157 \to 151 \to ....$ These transitions occur at temperatures $T(k) = n \times E_0(k)$, n a numerical constant. This picture is consistent with the observation that the reduction of resistance occurs in a very short temperature interval ΔT: $\Delta T/T \sim .04$.

A more concrete picture is obtained by decomposing the friction force to a sum of forces resulting from dropping from say $k = 151$ to $k = 157 163, 167, ...$ and being kicked back. This gives

$$F \ = \ K(k)v \ ,$$
$$K(k) \ = \ \sum_{k_i > k} \kappa(k_i) = \kappa(k_>) + K(k_>) \ . \tag{7.4.5}$$

The condition $F = qE$, $q = 2e$, gives for the conductivity defined by $j = nv = \sigma(k)E$, E electric field, the expression

$$\frac{1}{\sigma(k)} \ = \ \frac{K(k)}{nq} = \frac{\kappa(k_>)}{nq} + \frac{1}{\sigma(k_>)} \ . \tag{7.4.6}$$

What this means that the space-time sheets correspond effectively to resistors in series.

From the experimental findings for frog, for the transition from $k = 157$ to $k = 151$ the term $\kappa(157)$ must be by about a factor 10 larger than the sum of terms term $\kappa(k)$, $k > 157$. The fractal scaling

$$K(k) \quad \propto \quad \frac{1}{L^\alpha(k)} \propto 2^{-\alpha k/2} \tag{7.4.7}$$

with $\alpha \simeq 1.1$, suggests itself.

The standard classical model for the dissipative force implies that the force is inversely proportional to the free path $l(k)$ of the particle and by naïve scaling symmetry l would be naturally proportional to the p-adic length scale $l \propto L(k)$ giving $\alpha = 1$. $\alpha > 1$ for $K(k)$ means that the free path has a fractal dimension slightly larger than one. The anomalous dimension is due to the many-sheeted nature of the free paths implying the presence of the higher order terms in the expansion of $K(k)$. Indeed, in the lowest order the model based on the naïve scaling dimension -1 for $\kappa(k)$ predicts

$$\frac{\sigma(151)}{\sigma(157)} \simeq 1/8 - 1/64 \simeq .11 \tag{7.4.8}$$

in consistency with the measured reduction of the resistivity. Needless to say, this prediction provides a strong support for the p-adic length scale hypothesis and the notion of many-sheeted space-time.

7.4.4   Application At Axonal Level

It is interesting to apply the model for the breaking of super-conductivity in the case of axon.

Understanding the critical temperature

The model for the nerve pulse generation predicts that "bridges" are formed between $k = k_0 > 151$ (say $k_0 = 169$) and $k = 151$ space-time sheets making possible the flow of ions between cell interior and exterior. Super conductivity is broken provided that the temperature is sufficiently high. For electron Cooper pairs ($M = 2m_e$) the zero point kinetic energy at the cell membrane space-time sheet is from Eq. 7.4.4

$$E_0(k = 151) = n_1 \times 312.25 \text{ K} . \tag{7.4.9}$$

n_1 is some numerical constant not too far from unity. $n_1 = 1$ corresponds to a temperature 42.25 C. The identification as the critical temperature gives quite satisfactory agreement with the experimental values varying from 240 K to 300 K. Note that the requirement $T > T_{cr}$ for the physiological temperatures means that $k = 151$ cell membrane space-time sheet is the effective current carrier in the presence of larger space-time sheets.

If the flux tube connecting $k = 169$ and $k = 151$ space-time sheets contains a strong enough transversal electric field, the supra current can flow only in one direction. It seems that in the case of cell membrane the leakage of electronic Cooper pairs to the negatively charged cell interior is forbidden by this mechanism. The absence of the flux tubes between cell membrane and cell exterior assumed to be generated during the nerve pulse in the TGD based model of the nerve pulse [K95] in turn implies that the leakage cannot occur to or from $k = 169$ space-time sheets at all. Therefore both $k = 151$ and $k = 169$ space-time sheet might be genuinely super-conducting and only nerve pulse conduction would be accompanied by the breaking of super-conductivity.

Predictions for the critical temperature and resistance

Fractality allows to make definite quantitative predictions for the critical temperature.

1. For $k = 163$ conductivity the critical temperature is predicted to be by a factor $2^{157-151} = 64$ lower than for $k = 157$ conductivity. This gives $T_c(163) = 4.9$ K for $T_c(157) = 300$ K. The upper bound $T_c = 4$ K for the critical temperature for super-conductivity in molecular crystals is reported in [D70]. This would correspond to $T(157) = 240$ K measured in the case of frog. The predicted lowering of the resistance at this critical temperature for nerve conduction might be testable.

2. The observation that DNA attached between carbon and rhenium electrodes becomes super-conducting below the critical temperature of about 1 K for rhenium [I59] allows the possibility that DNA becomes super-conducting already at about $T_c(163) \simeq 4-5$ K but that the rhenium acts as the weak link in the super-conducting circuit.

3. Cell membrane thickness L might vary and the natural guess is that the critical temperature is inversely proportional to $1/L^2$. If this is the case, the ratio of cell membrane thicknesses for frog and rabbit should be

$$\frac{L(frog)}{L(rabbit)} = \sqrt{\frac{T(rabbit)}{T(frog)}} = \sqrt{5/4} = 1.12 \tag{7.4.10}$$

for $T(rabbit) = 300$ K and $T(frog) = 240$ K.

4. A further prediction following from the fractal model for the conductance (Eq. 7.4.7) is that also the $k = 157 \rightarrow 163$ at about 4-5 K involves a 10-fold reduction of resistance. Also this prediction might be testable for nerves.

What happens in saltation?

An interesting question is what happens in the saltation over the myelin sheathed portions of the nerve. According to the TGD based model of nerve [K92] [K95], the ME ("massless extremal", "topological light ray" moving with effective velocity equal to the conduction velocity of nerve pulse acts as a bridge between cell membrane ($k = 151$) and cell exterior ($k = 169$) space-time sheets and in this manner allows the leakage of ions from cell interior to exterior and vice versa inducing the physiological effects of nerve pulse. ME could propagate along the myelin sheath rather than along the axon inside. Therefore nerve pulse would not be generated. The following picture about saltation suggests itself.

1. The transformation of the nerve pulse to an electronic $k = 151$ or $k = 169$ supra current propagating rapidly through the myelin sheathed portion would make possible a rapid signal transmission without physiological effects. Inside myelin sheathed portions of the axon the leakage to $k = 169$ space-time sheets would be impossible by the mechanism described above irrespective of the value of the critical temperature.

2. Nerve pulse conduction involves also communication and interaction between different space-time sheets and therefore necessitates the leakage of electronic Cooper pairs from $k = 151$ cell membrane space-time sheet. Therefore the critical temperature must be below the range of the physiological temperatures. Endotherms have an evolutionary advantage since the higher critical temperature implies that the dissipative effects associated with the nerve pulse conduction are weaker.

   Whether electronic supra current in the myelin sheathed portions of the axon propagates along $k = 151$ or $k = 169$ space-time sheet or along both plus possibly along some other space-time sheets, remains unclear. Note that the critical temperature in myelin sheathed regions could be higher than the physiological temperature. The endogenous magnetic field $B = .2$ Gauss suggested by the work of Blackman and others corresponds to a flux tube radius $L = sqrt5/2 \times L_e(169) \simeq 1.58 L_e(169) = 17.7 L(169) \sim L(177) = 2^(5)L(127)$.

   It is interesting to notice that Evan Harris [J33] [J33] has developed a quantitative theory in which the tunnelling of electrons through the synaptic contact is the basic step of synaptic transfer. The theory applies also to ephapses in which electric transfer of the nerve pulse takes place. Theory explains the differences between ephapses and synapses and also the morphology of synapses and ephapses finds natural explanation. This kind of tunnelling might be induced by the formation of 151-169 ME contacts at presynaptic cell and 169-151 ME contacts at the postsynaptic cell.

7.5   Quantum Model For The Direct Currents Of Becker

Robert Becker [J24] proposed on basis of his experimental work that living matter behaves as a semiconductor in a wide range of length scales ranging from brain scale to the scale of entire body. Direct currents flowing only in preferred direction would be essential for the functioning of living manner in this framework.

One of the basic ideas of TGD inspired theory of living matter is that various currents, even ionic currents, are quantal currents. The first possibility is that they are Josephson currents associated with Josephson junctions but already this assumption more or less implies also quantal versions of direct currents.

TGD inspired model for nerve pulse assumes that ionic currents through the cell membrane are quantal currents. If they are Josephson currents, the situation is automatically stationary and dissipation is small as various anomalies suggest. One can criticize this assumption since the Compton length of ions for the ordinary value of Planck constant is so small that magnetic flux tubes carrying the current through the membrane look rather long in this length scale. Therefore either Planck constant should be rather large or one should have a non-ohmic quantum counterpart of a direct current in the case of ions and perhaps also protons in the case of neuronal membrane: electronic and perhaps also protonic currents could be still Josephson currents. This would conform with the low dissipation rate.

In the following the results related to laser induced healing, acupuncture, and DC currents are discussed first. The obvious question is whether these direct currents are actually supracurrents and whether they could be universal in living matter. A TGD inspired model for quantal direct currents is proposed and its possible implications for the model of nerve pulse are discussed.

Whether the model for quantum direct currents is consistent with the proposed vacuum extremal property of the cell membrane remains an open question but both options explain the special role of Ca^{++} currents and current of Na^{+} Cooper pairs in the generation of nerve pulse as in would take place in TGD Universe. In fact, it is not clear what one exactly means with the vacuum extremal property of cell membrane. Many-sheeted space-time (see **Fig. `http://tgdtheory.fi/ appfigures/manysheeted.jpg`** or **Fig.** 9 in the appendix of this book) allows to consider space-time sheets which can be both almost vacuum extremals and far from vacuum extremals. Also space-time sheets for which Planck constant is so large that both electronic and protonic Josephson currents become possible. Various pumps and channels could actually correspond to magnetic flux tubes along which various ionic supra currents or even Josephson currents can flow. The condition that both electronic and protonic supra currents are possible in same length scale leads to the hierarchy of Planck constants coming approximately as powers of $m_p/m_e \simeq 2^{11}$ proposed originally as a general truth. Radiation at Josephson frequency serves as a signature for Josephson currents.

In the following a TGD inspired quantum model for the direct currents of Becker as direct quantum currents is developed and shown to be consistent with what is known about nerve pulse generation.

7.5.1   Connection Between Laser Induced Healing, Acupuncture, And Association Of DC Currents With The Healing Of Wounds

The findings of Robert Becker (the book "The Body Electric: Electromagnetism and the Foundation of Life" by Becker and Selden, which can be found from web (see `http://tinyurl.com/ y8rbgebw`) [J24], meant a breakthrough in the development of bioelectromagnetics. One aspect of bioelectromagnetic phenomena was the discovery of Becker that DC currents and voltages play a pivotal role in various regeneration processes. Why this is the case is still poorly understood and Becker's book is a treasure trove for anyone ready to challenge existing dogmas. The general vision guiding Becker can be summarized by a citation from the introduction of the book.

Growth effects include the alteration of bone growth by electromagnetic energy, the restoration of partial limb regeneration in mammals by small direct currents, the inhibition of growth of implanted tumors by currents and fields, the effect upon cephalocaudal axis development in the regenerating flatworm in a polarity-dependent fashion by applied direct currents, and the production of morphological alterations in embryonic development by manipulation of the electrochemical species present in the environment. This partial list illustrates the great variety of known bioelectromagnetic phenomena.

The reported biological effects involve basic functions of living material that are under remarkably precise control by mechanisms which have, to date, escaped description in terms of biochemistry. This suggests that bioelectromagnetic phenomena are fundamental attributes of living things, ones that must have been present in the first living things. The traditional approach to biogenesis postulates that life began in an aqueous environment, with the development of complex molecules and their subsequent sequestration from the environment by membranous structures. The solid-state approach proposes an origin in complex crystalline structures that possess such properties as semiconductivity, photoconductivity, and piezoelectricity. All of the reported effects of electromagnetic forces seem to lend support to the latter hypothesis.

Observations relating to CNS

The following more quantitative findings, many of them due to Becker, are of special interest as one tries to understand the role of DC currents in TGD framework.

1. CNS and the rest of perineural tissue (tissue surrounding neurons including also glial cells) form a dipole-like structure with neural system in positive potential and perineural tissue in negative potential. There is also an electric field along the neuron in the direction of nerve pulse propagation (dendrites correspond to - and axon to +) (note that motor nerves and sensory nerves form a closed loop). Also microtubules within axon carry electric field and these fields are probably closely related by the many-sheeted variants of Gauss's and Faraday's laws implying that voltages along two different space-time sheets in contact at two points are the same in a static situation.

2. A longitudinal potential along front to back in the brain with the frontal lobes in negative potential with respect to occipital lobes and with a magnitude of few mV was discovered. The strength of the electric field correlates with the level of consciousness. As the potential becomes weaker and changes sign, consciousness is lost. Libet and Gerard observed traveling waves of potentials across the cortical layers (with speeds of about 6 m/s: TGD inspired model of nerve pulse predicts this kind of waves [K92]). Propagating potentials were also discovered in glial cells. The interpretation was in terms of electrical currents.

3. It was found that brain injury generated positive polarization so that the neurons ceased to function in an area much larger than the area of injury. Negative shifts of neuronal potentials were associated with incoming sensory stimuli and motor activity whereas sleep was associated with a positive shift. Very small voltages and currents could modulate the firing of neurons without affecting the resting potential. The "generating" potentials in sensory receptors inducing nerve pulse were found to be graded and non-propagating and the sign of the generating potential correlated with sensory input (say increase/reduction of pressure). Standard wisdom about cell membrane has difficulties in explaining these findings.

4. The natural hypothesis was that these electric fields are accompanied by DC currents. There are several experimental demonstrations for this. For instance, the deflection of assumed DC currents by an external magnetic field (Hall effect) was shown to lead to a loss of consciousness.

Observations relating to regeneration

The second class of experiments used artificial electrical currents to enhance regeneration of body parts. These currents are nowadays used in clinical practice to induce healing or retard tumor growth. Note that tissue regeneration is a genuine regeneration of an entire part of the organism rather than mere simple cell replication. Salamander limb generation is one of the most studied examples. Spontaneous regeneration becomes rare at higher evolutionary levels and for humans it occurs spontaneously only in the fractures of long bones.

1. An interesting series of experiments on Planaria, a species of simple flatworm with a primitive nervous system and simple head-to-tail axis of organization, was carried out. Electrical measurements indicated a simple head-tail dipole field. The animal had remarkable regenerative powers; it could be cut transversely into a number of segments, all of which would

regenerate a new total organism. The original head-tail axis was preserved in each regenerate, with that portion nearest the original head end becoming the head of the new organism. The hypothesis was that the original head-tail electrical vector persisted in the cut segments and provided the morphological information for the regenerate. The prediction was that the reversal of the electrical gradient by exposing the cut surface to an external current source of proper orientation should produce some reversal of the head-tail gradient in the regenerate. While performing the experiment it was found found that as the current levels were increased the first response was to form a head at each end of the regenerating segment. With still further increases in the current the expected reversal of the head-tail gradient did occur, indicating that the electrical gradient which naturally existed in these animals was capable of transmitting morphological information.

2. Tissue regeneration occurs only if some minimum amount of neural tissue is present suggesting that CNS plays a role in the process although the usual neural activity is absent. The repeated needling of the stump had positive effect on regeneration and the DC current was found to be proportional to innervation. Hence needling seems to stimulate innervation or at least inducing formation of DC currents. Something like this might occur also in the case of acupuncture.

3. Regeneration involves de-differentiation of cells to form a blastema from which the regenerated tissue is formed. Quite early it was learned that carcinogens induce de-differentiation of cells because of their steric properties and by making electron transfer possible and that denervation induces tumor formation. From these findings Becker concluded that the formation of blastema could be a relatively simple process analogous to tumor growth whereas the regeneration proper is a complex self-organization process during which the control by signals from CNS are necessary and possibly realized in terms of potential waves.

4. Regeneration is possible in salamanders but not in frogs. This motivated Becker and collaborators to compare these situations. In an amputated leg of both salamander and frog the original negative potential of approximately -1 mV was raised first to a positive value of about +10 mV. In the frog it returned smoothly to its original value without regeneration. In the salamander it returned over a period of three days to the original base line and then went to a much higher negative value around -20 mV (resting potential is around -70 mV) followed by a return to the original value once regeneration had occurred. Thus the large negative potential is necessary for the regeneration and responsible for the formation of blastema. Furthermore, artificial electron current also induced regeneration also in the case of the frog, even in the denervated situation. Thus the flow of electrons to the stump seems to be necessary for the formation of blastema and the difference between salamander and frog is that frog is not able to provide the needed electronic current although positive potential is present.

5. It was also learned that a so called neuroepidermal junction (NEJ) formed in the healing process of salamander stump was responsible for the regeneration in the presence of denervation. The conclusion was that the DC voltage and electronic current relevant for regeneration could be assigned the interface between CNS and tissue rather than to the entire nerve and the regeneration seemed to be a local process, perhaps a feed of metabolic energy driving self-organization. Furthermore, NEJ seemed to make possible the flow of electrons from CNS to the stump.

6. The red blood cells of animals other than mammals are complete and thus possess nuclei. Becker and collaborators observed that red blood cells also dedifferentiated to form blastemas. Being normally in a quiescent state, they are ideal for studying de-differentiation. It was found that the electric current acted as a trigger at the level of cell membrane inducing de-differentiation reflected as an increased amount of mRNA serving as marker of gene expression. Also pulsed magnetic field was found to trigger the de-differentiation, perhaps via induced electric field. By the way, the role of the cell membrane fits nicely with the TGD inspired view about DNA-cell membrane system as topological quantum computer with magnetic flux tubes that are assumed to connect DNA and cell membrane and serve as braid strands in TGD inspired model of DNA as topological quantum computer [K5].

7. The experiments of Becker and collaborators support the identification of the charge carriers of DC currents responsible for the formation of the stump's large negative potential as electrons. The test was based on the different temperature dependence of electronic and protonic conductivities. Electronic conductivity increases with temperature and protonic conductivity decreases and an increase was observed.

Gene activation by electrostatic fields?

The basic question concerns the method of activation. The discovery of chemists Guido Ebner and Guido Schuerch [J11] raises the hope that these ideas might be more than over-active imagination and their work also provides a concrete proposal for the activation mechanism. Ebner and Schuerch studied the effect of electrostatic fields on the growth and morphogenesis of various organisms. Germ, seeds, or eggs were placed between conducting plates creating an electric field in the range .5-2 kV/m: note that the Earth's electric field is in the range $.1 - 4$ kV/m and of the same order of magnitude.

The outcome was rather surprising and in the year 1989 their employer Ciba Geigy (now Novartis) applied for a patent "Method of enhanced fish breeding" [J11] for what is called Ciba Geigy effect. The researchers describe how fishes (trouts) develop and grow much better, if their eggs have been conditioned in an electrostatic field. The researchers also reporedt [J11] that the morphology of the fishes was altered to what seems to represent an ancient evolutionary form: this was not mentioned in the patent.

The chemists founded their own Institute of Pharmaceutical Research near Basel, where Guido Ebner applied for another very detailed patent, which was never granted. In the patent he describes the effect of electrostatic fields on several life forms (cress, wheat, corn, fern, microorganisms, bacteria) in their early stage of development. A clear change in the morphogenesis was observed. For instance, in one example fern had all sort of leaves in single plant apparently providing a series of snapshots about the evolution of the plant. The evolutionary age of the first leaf appeared to be about 300 million years whereas the last grown-up leaf looked close to its recent form.

If one takes these finding seriously, one must consider the possibility that the exposure to an electrostatic field can activate passive genes and change the gene expression so that older morphologies are expressed. The activation of not yet existing morphologies is probably more difficult since strong consistency conditions must be satisfied (activation of program requires activation of a proper hardware). This would suggest that genome is a kind of archive also containing also older genomes even potential genomes or that topological quantum computer programs [K5] determine the morphology to a certain extent and that external conditions such as electric fields determine the self-organization patterns characterizing these programs.

It is known that the developing embryo has an electric field along the head-tail axis and that this field plays an important role in the control of growth. These fields are much weaker than the fields used in the experiment. p-Adic length scale hierarchy however predicts an entire hierarchy of electric fields and living matter is indeed known to be full of electret structures. The strength of the electric field in some p-adic length scale related to DNA might somehow serve as the selector of the evolutionary age. The recapitulation of phylogeny during ontogeny could mean a gradual shift of the activated part of both genome and "memone" (as as menetic analog of genome: for a proposal of memetic code see [K52]), perhaps assignable to topological quantum computer programs realized as braidings, and be controlled by the gradually evolving electric field strength.

The finding that led Ebner to his discovery was that it was possible to "wake up" ancient bacteria by an exposure to an electrostatic field. The interpretation would be in terms of loading of metabolic batteries. This would also suggest that in the case of primitive life forms like bacteria the electric field of the Earth has served as metabolic energy source whereas in higher life forms endogenous electric fields have taken the role of Earth's electric field.

A TGD based model for the situation

On the basis of these observations one can try to develop a unified view about the effects of laser light, acupuncture, and DC currents. It is perhaps appropriate to start with the following - somewhat leading - questions inspired by a strong background prejudice that the healing process -

with control signals from CNS included - utilises the loading of many-sheeted metabolic batteries by supra currents as a basic mechanism.

The first series questions, observations, and ideas relates to the connection of DC currents with metabolism and ordinary biochemistry. The hierarchy of Planck constant is expected to be involved somehow.

1. How the DC currents relate to metabolism and ordinary biochemistry? For what purpose they are needed? The crucial point is that the energy of order 1 meV gained by electron in the electric field is much below the metabolic energy quantum and also thermal energy so that the interpretation in terms of metabolic energy quantum does not look promising. This forces to consider the possibility that the basic role of electric field is to drive electrons to where they are needed, say wounded part of tissue in positive potential and thus atttracting electrons. Electrons are indeed needed by the electron transport cycle appearing in both photosynthesis and cell respiration since the transport cycle induces leakage of electrons due to the formation of ROS (reactive oxygen species) such as O_2^-. The purpose of electronic Becker currents would be therefore the re-establishment of metabolism.

   The change of the sign of the Becker potential to positive induce a loss of electrons and reduced metabolism. This could explain why consciousness is lost when the sign of Becker potential is changed or electrons are deviated by Hall effect. Wound damages the connections of the tissue to the organism and the transfer of electrons compensating for leaked electrons is prevented since Becker potential changes sign. The regeneration induced by an artificial Becker potential of correct sign would induce healing by re-establishing the electron feed.

The crucial question concerns the role of electrons. It seems that in all situations electron flow to the damaged tissue induces healing. Why electrons generating negative potential should help in healing? The first input is TGD model [K86] [L23] for the findings of Pollack [L23] involves the connection of dark matter hierarchy $h_{eff} = n \times h$ with negentropic entanglement characterized by density matrix reducing to $n \times n$ unit matrix for entanglement matrix proportional to a unitary matrix. In infinite-dimensional case the divisor is infinite unless one uses von Neumann's hyperfinite factor of type II$_1$ for which the normalization factor can be taken to be unity: in the case of quantum groups this corresponds to using quantum trace instead of the ordinary one. A further input is the observation that the gravitational Planck constant h_{gr} explaining planetary Bohr quantization rules can be equal to h_{eff} in living matter for microscopic systems like elementary particles, atoms, and ions, even molecules [K109, K90].

1. Pollack's findings about fourth phase of water formed when external energy feed induces formation of negatively charged exclusion zones of water obeying stoichiometry $H_{1.5}O$ with 1/4: th of protons going to the complement of exclusion zone. Something similar might happen also now.

2. In TGD framework this process is explained as a formation dark phase of protons at the magnetic flux tubes associated with the exclusion zone with dark protons realizing genetic code so that one obtains what might be regarded as primitive primordial life form.

3. There is evidence for a huge anomalous gravimagnetic Thomson field in rotating super conductors. Thomson field is proportional to square of Planck constant h_{eff} and TGD explanation is that large h_{gr} phase is formed at gravitational flux tubes. The assumption $h_{gr} = h_{eff}$ in elementary particle and atomic scales is possible and is consistent with the hypothesis that bio-photons in visible and UV energy range correspond to decay products of dark EEG photons.

4. $\hbar_{gr}$ can be generalized to $\hbar_{em} = -Z_1 Z_2 e^2/v_0$: v_0 would be typical rotational velocity in a system with opposite charges Z_1 and Z_2. Exclusion zone would be good example. For ATP v_0 would be rotational velocity of ATP. For exclusion zone v_0 could be rotational velocity of Cooper pairs in magnetic field associated with flux tubes or walls or rotational velocity of magnetic body. $Z_2 = -Z_1$ is natural assumption by charge neutrality.

5. In this framework the feed of electrons would increase the value of h_{eff} by increasing the negative charge associated with the analog of exclusion zone accompanying the wound and

induce also a flow of dark protons to the magnetic flux tubes associated with the magnetic body of the analog of exclusion zone.

6. The DC currents would be needed because the damage of the tissue means that the $\hbar_{eff} = \hbar_{em} = Z^2 e^2/v_0$ is reduced for a pair formed by damaged system and its complement. Healing would be essentially attempt to increase h_{eff} to its original value. The parameter Z^2 is reduced and must be increased to its original value and perhaps even to a higher value since the larger ger the value of h_{eff} is, the richer the negentropic resources of system are. The transfer of electrons to the system analogous to exclusion zone induces transfer of dark protons to the magnetic flux quanta of the magnetic body of the system. Recall that dark proton strings at flux tubes could be analogs of dark nuclei and that the model for dark nucleons allows to identify nucleon states as counterparts of DNA, RNA, amino-acids and even tRNA. This leads to a model of prebiotic lifeforms [K53].

7. ATP synthase transforming ADP to ATP involves rotating shaft and one can ask whether the velocity parameter v_0 appearing in the expression for $\hbar_{em}$ equals to the rotation speed of the shaft. This predicts that the value of $\hbar_{em}$ to be same order as $\hbar_{eff}$ and $\hbar_{gr}$ for Earth-electron system assuming that v_0 corresponds to the rotation velocity at the surface of Earth. The assumption $h_{eff} = h_{gr} = h_{em}$ makes it possible for the gravitational and em flux tubes to reconnect.

8. The original guess was that electrons to provide energy giving rise to the formation of ATP in cell respiration and photosynthesis. Electrons themselves receive their energy either from the oxidation of molecules or from solar photons. This model is consistent with the model above since electron transport chain is crucial for cell transpiration and needs both electrons and dark protons located at the dark flux tubes associated with the exclusion zones. Dark protons would flow through the ATP synthase attached to mitochodrial membrane and liberate dark cyclotron energy if the value of the magnetic fields associated with the flux tube is different for the interior and exterior portions of the flux tube [K44, K85].

The experimental support for the role of bio-photons in living matter is accumulating and a natural question concerns their role in metabolism. In TGD framework dark photons with large value of $\hbar_{eff}$ with energy of visible photon can transform to ordinary photons of same energy with some - presumably rather small - probability, and would be interpreted as bio-photons. Could dark photons take the role of solar photons and provide in some situations energy to the electrons in the electron transport cycle? This would mean a non-conventional non-local mechanism of metabolism. The effects of laser light on tissue suggest that laser light indeed takes the role of solar light and feed energy to the electron transport cycle transforming it to the energy of high energy phosphate bond of ATP. A more detailed TGD inspired view about what might happen is discussed in [K58].

One can consider also the possibility that quantum credit card mechanism (remote metabolism) could be at work in some the situations when chemical metabolic energy sources are absent. Damaged tissue might define this kind of exceptional situation. This brings in mind the strange ability of plants suffering under-nutrition to attract insects responsible for their pollination observed by Callahan, who has also reported that plants and insects communicate using infrared light which according to his findings serves as a sensor input in insect olfaction [I32]: also in this case quantum credit card mechanism building magnetic flux tube bridges guiding the insects to the plant might be at work. The electrons which have gained 1 meV energy during travel along pairs formed by MEs and parallel magnetic flux tubes (meridians), could send negative energy dark photons with energy of order -.5 eV to gain same positive energy allowing to get over the semiconductor junction after they have arrived to the damaged tissue. These negative energy photons would be absorbed by a metabolic energy store (ATP in mitochondria transforming to ADP) in the healthy part of the organism.

$h_{eff} = h_{em}$ implies that the spectrum of bio-photons originating from dark cyclotron photons is universal having no dependence on ion mass and in visible and UV range, which is also the range for molecular excitation energies. Dark cyclotron photons decaying to bio-photons would therefore allow magnetic body to control biochemistry by resonant absorption inducing transitions of molecules.

The original model for the charging of the metabolic batteries and for effective semi-conductor junction assumed that the electrons of supra current are transferred to smaller space-time sheets.

1. For ground state electrons this requires energy which is at least the difference of zero point kinetic energies of electron at the two space-time sheets. This energy should be of the order of fundamental metabolic energy quantum of about .5 eV.

   For Cooper pairs of electrons the sheet should correspond to p-adic length scale of order $L_e(k_e = 149) = 10$ nm, the thickness of lipid layer of cell membrane. For single proton corresponding scale would be $L_e(k_p = 139) \simeq 2^{-12}L_e(151)$ from $m_p/2m_e \simeq 2^{10}$ and $E_{0,p}/E_{0,2e} = (2m_e/m_p) \times (L_e(k_e)/L_e(k_p))^2 = (2m_e/m_p) \times 2^{k_e-k_p} \sim 1$.

   This suggests that electron Cooper pair is kicked to a smaller space-time sheet assignable to a mitochondrial lipid layer having $k_e = 149$. The larger space-time sheet could be that of cell membrane with $k = 151$. For protons the zero point kinetic energies at these space-time sheets are by a factor $2m_e/m_p$ lower and of the order of .5 meV. This happens to be of the same order of magnitude as the energy gained by proton or electron in the Becker potential. May be this is not an accident.

   There is also a second intriguing quantitative coincidence. In the absence of an action potential, acetylcholine vesicles spontaneously leak into the synaptic junction and cause very small de-polarizations in the postsynaptic membrane known as miniature end plate potentials (see http://tinyurl.com/y98zhxzh) (mEPSP) of magnitude .5 mV. These potentials are too small to generate action potential but together they can sum up to the needed action potential. Maybe the interpretation in terms of proton kicked to lipid layer space-time sheet might make sense.

2. The re-charging mechanism should relate directly to ADP→ ATP process occurring during electronic transport cycle in mitochondrial membrane. The connection with metabolism forces to ask how the formation of high energy phosphate bond in the addition of phosphate to ADP relates to the transfer of electrons to smaller space-time sheet. Somehow the energy of electrons must go to the formation of this bond: perhaps the dropping of electron back to larger space-time sheet transfers the energy to the high energy phosphate bond.

   In many-sheeted space-time particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries of space-time sheet of a given system. Also p-adic phase transition increasing the size of the space-time sheet could take place and the liberated energy would correspond to the reduction of zero point kinetic energy. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant h_{eff} so that cyclotron energy would be liberated.

3. The transfer of particles between space-time sheets with different p-adic length scales is not the only one that one can consider, and recently a more elegant mechanism has emerged [K58]. If the particles are free, a phase transition in which the p-adic prime of the space-time sheet containing particles decreases adiabatically increases the scale of kinetic energy but leaves particle quantum numbers unchanged. If the same happens for charge particles at magnetic flux tubes, similar increase of cyclotron energy scale takes place since magnetic field strength increase to conserve magnetic flux. The predictions are in good approximation the same as for the original model. If the phase transition reducing p-adic length scale is accompanied by a compensating increase of Planck constant, the size scale of space-time sheet remains unaffected but metabolic batteries are loaded. The reversal of this phase transition liberates metabolic energy. What is important that metabolic energy and negentropic entanglement (measured in terms of the value of Planck constant) are closely correlated for this mechanism. The loading/liberation of energy is also a quantum coherent process.

4. Acupuncture and the application of DC current are known to induce the generation of endorphins. Do endorphins contribute to well-being by reducing the pain? In TGD framework the deeper level interpretation of metabolism is as a provider of negentropic entanglement in

turn giving rise to well-being. Are endorphins kind of negentropy packets or just conscious signals about the improved situation?

Second series of questions, observations, and ideas relates to the meridians, acu points, and "chi".

1. A permanent potential difference of same sign between head and tail could mean an accumulation of positive and negative charges to the ends of the of the system if only electron currents are present. If both electron and proton currents with opposite directions are present, there is no accumulation of charge but there is an accumulation of protons and electrons. Probably there exists a pumping mechanism forcing the electrons (and possibly also protons) to move against the potential gradient from the tail back to the head. This however requires metabolic energy and the simplest source of this energy would be just the energy of electrons otherwise used to generate ATP. If so, the leakage would not be an unavoidable dissipative effect but a way to avoid charge accumulation.

   If the pumping mechanism is not at work, this situation cannot continue for ever and the sign of the potential difference must eventually change and induce loss of consciousness. The simplest possibility is that the potential difference changes sign rhythmically. A natural question is whether the sleep-awake rhythm is unavoidable and corresponds to the oscillatory behavior of the head-to-tail voltage.

   "Chi" would correspond electrons or their Cooper pairs in this picture. Abnormal chi flow (reduced flow, flow in wrong direction, accumulation of chi) would cause various problems including also insomnia in which too much electron charge tends to accumulate.

3. What is the nature of acupuncture meridians, what kind of currents flow along them, and why are they not directly observed? The most natural identification in TGD Universe would be in terms of magnetic flux tubes accompanied by parallel massless extremals (MEs) making possible also the propagation of dark photons used for control purposes and perhaps even in metabolism as already discussed. Dark currents along pairs of MEs and magnetic flux tubes are ideal for the transfoer of particles and energy.

   If the length of the superconducting "wire" is long in the scale defined by the appropriate quantum scale proportional to $\hbar$, the classical picture makes sense and charge carriers can be said to accelerate and gain energy ZeV. For large values of $\hbar_{eff}$ an oscillating Josephson current would be in question. Since Becker currents are associated with CNS, it would be natural to associate the meridians with neural pathways although this assignment is not necessary. Magnetic flux tube system defined kind of magnetic circulation which could serve as a template for the neural pathways. The transfer of energy with minimal dissipation would explain why a semiconductor like property is needed and why acupuncture points have a high conductivity value.

4. What about acu-points? Acu points are known to be in negative potential normally. This suggests that the density of electrons or their Cooper pairs at them is higher than elsewhere in the meridian. Could they server as kind of electron stores providing electrons to their environment to compensate for losses caused by ROS. This would make possible higher metabolic activity in presence of nutrient molecules since the rate for the electron transform cycle should be proportional to the density of energizable electrons, "chi".

   When the potential of the acu-point is reduced or become positive, under-nutrition follows. This should relate to various symptoms like pain at acupuncture points. Acupuncture needle as an electronic conductor would develop a charge distribution with a concentration of electrons to the acu-point, and would re-establish the metabolic activity. Pain would be signature of lack of negentropic entanglement (see **Fig. http://tgdtheory.fi/appfigures/cat.jpg** or **Fig. ??** in the appendix of this book) and positive/negative coloring of emotions and sensations would quite generally correlate with the amount of negentropic entanglement.

5. Nanna Goldman *et al* have provided empirical evidence (see http://tinyurl.com/4to42pc) [I56] for the expectation that the healing effect of the acupuncture involves metabolism (see the popular article in Sciencedaily (see http://tinyurl.com/3734uub) [I33]).

The group has found that adenosine is essential for the pain killing effects of acupuncture. For mice with a normal adenosine level acupuncture reduced dis-comfort by two-thirds. In special "adenosine receptor knock-out mice" acupuncture had no effect. When adenosine was turned on in the tissues, the discomfort was reduced even in the absence of acupuncture. During and after an acupuncture treatment, the level of adenosin in tissues near the needles was 24 times higher than before the treatment. In the abstract of the article it is stated that it is known for long time that acupuncture generates signals which induce brain to generate natural pain killing endorphins but that also adenosine acts as a natural pain killer.

Adenosine is the basic building block of AXP, X=M, D, T (adenosin-X-phosphate, X=mono, di, tri). Therefore the findings suggest that the flow of electrons from the needle to acu point loads metabolic batteries by providing electrons to electron transport cycle needed to generate ATP. Adenosine could be partially generated as decay products of AXPs. Tissue itself could increase adenosine concentration to make possible its transformation to AXP utilizing electric field energy. From the popular article one cannot conclude whether the authors propose a connection with metabolism. The results are consistent with the assumption that the AXPs generated from adenosin accompany negentropic entanglement. This can occur in the scale of entire body and meridians could also make possible direct signalling with brain.

How can understand the semiconducting character of Becker's DC currents?

1. Becker assigns to the system involved with DC currents an effective semiconductor property. Could the effective semiconductor property be due the fact that the transfer of charge carriers to a smaller space-time sheet by first accelerating them in electric field is analogous to the transfer of electrons between conduction bands in semiconductor junction? If so, semiconductor property would be a direct signature of the realization of the metabolic energy quanta as zero point kinetic energies. For metabolic energy quantum of order .5 eV this however makes sense only if the electrons transferred to the smaller space-time sheet have energy slightly below the minimum energy for the transfer to the smaller space-time sheet in absence of the Becker potential. The situation would be critical and 1 mV voltage could serve as a kind of control knob.

   One can imagine the analog of this mechanism also when the external energy feed corresponds to a phase transition reducing p-adic length scale and increasing Planck constant so that the size of the space-time sheet remains unaffected. Again 1 mV voltage would have the role of control knob.

2. Supra currents flowing along magnetic flux tubes would make possible dissipation-free loading of metabolic energy batteries. This even when oscillating Josephson currents are in question since the transformation to ohmic currents in semiconductor junction makes possible energy transfer only during second half of oscillation period. Could this be a universal mechanism applying to various stages of the regeneration process? In quantal situation the metabolic energy quanta have very precise values as indeed required.

3. The findings of Becker provide support for electronic DC currents. The Cooper pairs of electrons are indeed the best candidates for the carriers of supra current by their small mass. In the minimal situation the currents defined by leaked electrons moving against potential gradient (utilising the energy used otherwise to generate ATP) could compensate the Becker currents and give rise to closed current loops without charge accumulation. If the electronic DC currents observed by Becker are much stronger than needed to compensate for the local electron leakage, a larger metabolically driven return current is needed to guarantee local charge neutrality. These currents seem to be assignable to CNS: maybe the two electron currents could be associated with sensory and motor pathways. An interesting question whether sympathetic-parasympathetic dichotomy also relates to electron currents in opposite directions.

4. Could also dark protonic and even ionic DC currents be present and running along their own flux tubes and perhaps defining cyclotron Bose-Einstein condensates? How large the scale of flux tubes can be: could it be much larger than that of biological body (by simple argument magnetic body should have layers with even size scale of Earth). What is the

possible connection with cell respiration? When single ATP is generated, three protons are are pumped through the mitochondrial membrane utilising the energy liberated in electron transport cycle. This does not however require protonic currents in longer scales.

5. In regeneration process NEJs are formed. They could consist of pairs of MEs and magnetic flux tube mediating the electronic DC current during blastema generation and regeneration proper during which also control signals from CNS would be present. Since NEJs seems to resemble cell membranes in some respects, the ideas inspired by the model of cell membrane and DNA as TQC can be used. The model for nerve pulse and the model for DNA as topological quantum computer suggest that dark ionic currents flowing along magnetic flux tubes characterised by a large value of the effective Planck constant are involved with both meridians and NEJs. Magnetic flux tubes can act as DC current wires or Josephson junctions generating oscillatory supra currents of ions and electrons. Also for large values of the effective Planck constant meridians look short in the relevant dark length scale and could act as Josephson junctions carrying oscillatory Josephson currents.

One can raise also questions about the relationship between DC currents and de-differentiation.

1. Could cell de-differentiation be caused by the presence of Becker's DC current? Also acupuncture is known to induce de-differentiation. Could the mere ability to charge metabolic energy batteries provided by electron feed induce de-differentiation, which manifests as an increased genetic expression? Can one see differentiation as an eliminative process forced by the reduction of the electron feed and inducing a selective reduction of gene expression? If this were the case, de-differentiation could be induced by a feed of surplus electrons to the system using either external electron current or additional electric field. Local electron density would correlate negatively with the degree of differentiation.

2. In this framework it might be possible to understand the claimed effects of external electric fields on the development of plants and fishes. In this case rejuvenation means return to the earlier evolutionary stages. Maybe ontogeny-recapitulates-phylogeny principle might allow to understand this if genome in some sense contains archive about earlier stages of evolution. This archive might be virtual and realised by an epigenetic mechanism selecting different patterns of gene expression using the same genome.

   If this is the case, the density of electrons or their Cooper pairs - "chi" - possessed by the cell would serve as a measure for the biological age of the cell and the meridian system feeding "chi" would serve as a rejuvenating agent with respect to gene expression. The average density of dark electrons would serve as a measure for the age of cell: the larger the density the higher the metabolic activity and the lower the biological age.

7.5.2 Quantum Model For Effective Semiconductor Property

Becker [J24] summarizes his findings by stating that living matter is an effective semiconductor. There are pairs of structures in positive and negative potential in various scales and the current between the plates of this effective capacitor flows when above some minimum potential difference. The current flows from positive to negative pole and could be an electron current. Also proton current in the opposite direction can be considered but the electron current is experimentally favored. For instance consciousness is lost when a magnetic field is used to deflect the current.

In TGD framework natural carriers of these currents would be magnetic flux tubes also carrying electric fields. A very simple deformation of the embedding of a constant longitudinal magnetic field also gives longitudinal electric field. With a slight generalization one obtains helical electric and magnetic fields. A crucial difference is that these currents would be quantal rather than ohmic currents even in the length scale of the biological body and even longer scales assignable to the magnetic body.

The following argument allows us to understand the physical situation.

1. A precise everyday analogy is vertical motion in the gravitational field of the Earth between surface and some target at given height h. If the kinetic energy is high enough, the particle reaches the target. If not, the particle falls back. In the quantum case one expects that the

latter situation corresponds to a very small probability amplitude at the target (tunnelling to classically forbidden kinematic region).

2. Now the electric field replaces the gravitational field. Suppose that the classical electric force experienced by the particle is towards the capacitor plate taking the role of the surface of Earth. Below critical field strength the charged particle cannot reach the target classically and quantum mechanically this occurs only by tunnelling with vanishingly small probability.

3. Particles with opposite value of charge experience a force which accelerates them and classically they certainly reach the second plate. What happens in a quantum situation? It seems that this situation is essentially identical with the first one: one has linear potential in finite interval and wave functions are localized in this range. One can equivalently regard these states as localized near the second capacitor plate.

4. A good analogy is provided by atoms: classically the electron would end down at the nucleus but quantization prevents this. One can imagine also now stationary solutions for which the electric currents for individual charges vanish at the plates although classically there would be a current in another direction. Also quantum mechanically non-vanishing conserved current is possible: all depends on boundary conditions.

Basic model

Consider now the situation at more quantitative level.

1. One can assign complex order parameters Ψ_k to various Bose-Einstein condensates of supra phases and obey Schrödinger equation

$$i\partial_t \Psi_k \;\;=\;\; (-\frac{\hbar^2}{2m_k}\partial_z^2 + q_k Ez)\Psi_k \;\;. \tag{7.5.1}$$

Here it is assumed that the situation is effectively one-dimensional. E is the value of constant electric field.

2. The Schrödinger equation becomes non-linear, when one expresses the electric field in terms of the total surface charge density associated with the plates of effective capacitor. In absence of external electric field it is natural to assume that the net surface charge densities σ at the plates are of opposite sign so that the electric field inside the capacitor is proportional to

$$\sigma \;\;=\;\; E = \sum \sigma_i = \sum_i q_i \overline{\Psi}_i \Psi_i \;\;. \tag{7.5.2}$$

This gives rise to a non-linear term completely analogous to that in non-linear Schrödinger equation. A more general situation corresponds to a situation in which the region interval $[a, b]$ bounded by capacitor plates a and b belongs to a flux longer tube like structure $[A, B]$: $[a, b] \subset [A, B]$. In this case one has

$$E_{tot} \;\;=\;\; E + E_0 \;\;. \tag{7.5.3}$$

This option is needed to explain the observations of Becker that the local strengthening of electric field increases the electron current: this would be the case in the model to be discussed if this field has a direct opposite to the background field E_0. One could also interpret E as quantized part of the electric field and E_0 as classical contribution.

3. The electric currents are given by

$$j_k = \frac{i\hbar q_k}{2m_k}\overline{\Psi}_k \overset{\leftrightarrow}{\partial_z} \Psi_k \ . \tag{7.5.4}$$

In stationary situation the net current must vanish:

$$\sum_k j_k = 0 \ . \tag{7.5.5}$$

A stronger condition is that individual currents vanish at the plates:

$$j_k = 0 \ . \tag{7.5.6}$$

It must be emphasized that this condition does not make sense classically.

Explicit form of Schrödinger equation

Consider now the explicit form of Schrödinger equation in a given electric field.

1. The equation is easy to solve by writing the solution ansatz in polar form (the index k labelling the charge particle species will be dropped for notational convenience).

$$\Psi = R(a\,exp(iU) + b\,exp(-iU))exp(-iE_n t) \tag{7.5.7}$$

For real solutions current vanishes identically and this is something which is not possible classically. It is convenient to restrict the consideration to stationary solutions, which are energy eigen states with energy value E_n and express the general solution in terms of these.

2. The Schrödinger equation reduces with the change of variable

$$z \rightarrow \frac{(z - z_0)}{z_1} \equiv x \ ,$$

$$z_0 = \frac{E_n}{qE} \ , \ z_1 = (\frac{\hbar^2}{2mqE})^{1/3} \ . \tag{7.5.8}$$

to

$$(\partial_x^2 + x)\Psi = 0 \ . \tag{7.5.9}$$

The range $[0, z_0]$ for z is mapped to the range $[-z_0/z_1, 0]$. z_0/z_1 has positive sign as is easy to verify. The value range of x is therefore negative irrespective of the sign of qE. This is the differential equation for Airy functions (see http://tinyurl.com/6b8yh7) [B1]. Airy functions are encountered in WKB approximation obtained by linearing the potential function: $V(x) = ax + b + O(x^2)$.

The change of variable leads automatically to solutions restricted near the plate where the situation is completely analogous to that in the gravitational field of the Earth. For stationary solutions a test charge in a given background field would be localized near the capacitor plate with opposite sign of charge. A strong background field could be created by charges which do not correspond to the ionic charges defining ionic currents. Electrons and protons could define this field possibly associated with flux tubes considerably longer than the distance between capacitor plates.

3. Using the polar representation $\Psi = Rexp(iU)$ Schrödinger equation reduces to two equations

$$
\begin{aligned}
\left[(\partial_x^2 - U_x^2 + x)R\right]cos(U) &+ \left[U_{xx} + 2\partial_x R\partial_x U\right]sin(U) = 0 \ , \\
\left[(\partial_x^2 - U_x^2 + x)R\right]sin(U) &- \left[U_{xx} - 2\partial_x R\partial_x U\right]cos(U) = 0 \ .
\end{aligned}
\tag{7.5.10}
$$

Note that both (R, U) and $(R, -U)$ represent solutions for given value of energy so that the solution can be chosen to be proportional to $cos(U)$ or $sin(U)$. The electric current j is conserved and equal to the current at $x = 0$ and given by

$$
j \quad = \quad \frac{\hbar}{2m}\frac{U_x}{z_1}R^2 \ , \quad z_1 = (\frac{\hbar}{2mqE})^{1/3} \ .
\tag{7.5.11}
$$

The current vanishes if either U_z is zero or if the solution is of form $\Psi = Rsin(U)$.

Semiclassical treatment

In semiclassical approximation the potential is regarded as varying so slowly that it can be regarded as a constant. In this situation one can write the solution of form $Rexp(iU)$ as

$$
\Psi \quad = \quad R_0 exp\left(\frac{i}{\hbar}\int_0^z \sqrt{2m}\sqrt{E - qEz}dz\right) = R_0 exp\left(i\int_0^x x^{1/2}dx\right) \ .
\tag{7.5.12}
$$

The plate at which the initial values are given can be chosen so that the electric force is analogous to gravitation at the surface of Earth. This requires only to replace the coordinate z with a new one, vanishing at the plate in question - and gives to the energies a positive shift $E_0 = qE_0h$.

1. The semiclassical treatment of the equation leads to Bohr rules

$$
\frac{\oint p_z dz}{\hbar} \quad = \quad \frac{2}{\hbar}\int_0^h p_z dz = n \ .
\tag{7.5.13}
$$

This gives

$$
\frac{\oint p_z dz}{\hbar} \quad = \quad \frac{2\sqrt{2m}}{\hbar}\int_0^h \sqrt{E_n - qEz}dz = 2\int_0^{x_0} x^{1/2} = \frac{4}{3}x_0^{3/2} = n \ .
\tag{7.5.14}
$$

Note that the turning point for classical orbit corresponds to $z_{max} = E_n/qE$.

2. One obtains

$$
E_n \quad = \quad \frac{1}{2}(\frac{nqE\hbar^2}{r\sqrt{m}})^{2/3} \ , \quad r = \int_0^1 (1-u)^{1/2}du = \frac{2}{3} \ .
\tag{7.5.15}
$$

The value of z_{max} is

$$
z_{max} \quad = \quad \frac{E_n}{qE} = \frac{n^{2/3}}{2r^{2/3}}(\frac{\hbar^2}{qEm})^{1/3} \ .
\tag{7.5.16}
$$

3. The approximation $R = R_0 = constant$ can make sense only if the position of the second plate is below z_{max}. This is possible if the value of n is large enough ($n^{2/3}$ proportionality), if the mass m of the charged particle is small enough ($m^{-1/3}$ proportionality) raising the electron and also the proton to a special position, or if the strength of the electric field is small enough ($E^{-1/3}$ proportionality). The value z_{max} is proportional to $\hbar^{2/3}$ so that a phase transition increasing Planck constant can induce current flow.

Possible quantum biological applications

The proposed model for quantum currents could provide quantum explanation for the effective semiconductor property of Becker's DC currents.

1. The original situation would be stationary with no currents flowing. The application of an external electric field in the correct direction would reduce the voltage below the critical value and currents would start to flow. This is consistent with Becker's findings if there is a background electric field E_0 with direction opposite to that of the applied field has a direction opposite to E_0 so that the field strength experienced by charged particles is reduced and it is easier for them to reach the second plate.

2. Becker's DC currents appear in several scales. They are assigned with the pairs formed by CNS and perineural tissue (this includes also glia cells) and by frontal and occipital lobes. Acupuncture could involve the generation of a DC supra current. The mechanism would be essential in the healing. Also the mechanism generating qualia could involve generation of supra currents and dielectric breakdown for them. The role of the magnetic flux tubes in TGD inspired biology suggests that the mechanism could be universal. If this were the case one might even speak about a Golden Road to the understanding of living matter at the basic level.

Even the generation of nerve pulse [K92] might be understood in terms of this mechanism. One can argue that neurons have a higher evolutionary level than the system pairs to which only electron currents or electron and proton currents can be assigned. This is because the value of the effective Planck constant is higher for the magnetic flux tubes carrying the quantal ionic currents.

1. For Bose-Einstein condensate the simplest choice is $n = 1$ at both plates. The energy eigenvalues would naturally differ by the shift $E_0 = qE_0h$ at the two plates for a given particle type. Under these assumptions the current can flow appreciably only if the voltage is below the minimum value. This is certainly a surprising conclusion but brings in mind what happens in the case of neuronal membrane. Indeed, hyper-polarization has a stabilizing - something difficult to understand classically but natural quantum mechanically.

2. The reduction of membrane potential slightly below the resting potential generates nerve pulse. Also a phase transition increasing the value of the effective Planck constant might give rise to quantal direct currents and generate flow of ionic currents giving rise to nerve pulse. Stationary solutions are located near either capacitor plate. What comes to mind is that the nerve pulse involves a temporary change of the capacitor plate with this property.

3. If the electron and proton currents flow as direct currents, one encounters a problem. Nerve pulse should begin with direct electronic currents and be followed by direct protonic currents and only later ions should enter the game if at all. The existing model for nerve pulse however assumes that at least electrons flow as oscillating Josephson currents rather than direct quantal currents. This is quite possible and makes sense if the cell membrane thickness is small - that is comparable to electron Compton length as assumed in large $\hbar$ model for the nerve pulse. This assumption might be necessary also for proton and would make sense if the Planck constant for protonic flux tubes is large enough. For ions the Compton length would be much smaller than the thickness of cell membrane and direct currents would be natural.

   If the value of the effective Planck constant is the same for biologically important ions, direct quantum currents would be generated in definite order since in $h < z_{max}$ one has $z_{max} \propto m^{-1/3} \propto A^{-1/3}$. The lightest ions would start to flow first.

   (a) Nerve pulses canbe generated by voltage gated channels for potassium and calcium. Voltage gated channels would correspond to magnetic flux tubes carrying electric field. For voltage gated channels Na^+ ions with atomic weight $A = 23$ and nuclear charge $Z = 11$ start to flow first, then K^+ ions with atomic weight $A = 39$ and $Z = 19$ follow. This conforms with the prediction that the lightest ions flow first. The nerve pulse duration is of the order of 1 millisecond at the most.

(b) Nerve pulses can be also generated by voltage gated Ca^{+2} channels. In this case the duration can be 100 ms and even longer. Ca has $A = 40$ and $Z = 20$. The proper parameter is $x = r^2/qA$, $r = \hbar/\hbar_0$. One has

$$\frac{x(Ca^{++})}{x(Na^+)} = (\frac{r(Ca^{++})}{r(Na^+)})^2 \times \frac{23}{2 \times 40} \quad . \tag{7.5.17}$$

$r^2(Ca_{++}) \sim 2r^2(Na_+)$ would allow to compensate for the increased weight and charge of Ca_{++} ions.

4. The objection is that Na^+ and K^+ are not bosons and therefore cannot form Bose-Einstein condensates. The first possibility is that one has Cooper pairs of these ions. This would imply

$$\frac{x(Ca^{++})}{x(2Na^+)} = (\frac{r(Ca^{++})}{r(Na^+)})^2 \times \frac{23}{20} \quad .$$

Ca^{++} and Na^+ pair would be in very similar position for a given value of Planck constant. This is a highly satisfactory prediction. Another manner to circumvent the problem is more science fictive and assumes that the Na^+ ions are exotic nuclei behaving chemically as Na^+ but having one charged color bond between nucleons [L3].

It remains to be seen whether this model is consistent with the model of cell membrane as almost vacuum extremal or whether the vacuum extremal based model could be modified by treating ionic currents as direct currents. In the vacuum extremal model classical Z^0 gauge potential is present and would give a contribution to the counterpart of Schrödinger equation. The ratio $x(Ca^{++})/x(2Na^+)$ for the parameter $x = r^2/q(A - Z)A$ (em charge q is replaced with neutron number in good approximation) equals to 1.38 and is not therefore very far from unity.

The many-sheetedness of space-time is expected to play a key role and one should precisely specify which sheets are almost vacuum extremals and which sheets are far from vacuum extremals. One expects that magnetic flux tubes are far from vacuum extremals and if voltage gated ionic channels are magnetic flux tubes, the proposed model might be consistent with the model of cell membrane as almost vacuum extremal.

The effects of ELF em fields on vertebrate brain

The effects of ELF em fields on vertebrate brain occur both in frequency and amplitude windows. Frequency windows can be understood if the effect occur at cyclotron frequencies and correspond to absorption of large $\hbar$ photons. A finite variation width for the strength of magnetic field gives rise to a frequency window. The observed quantal character of these effects occurring at harmonics of fundamental frequencies leads to the idea about cyclotron Bose-Einstein condensates as macroscopic quantum phases. The above considerations support the assumption that fermionic ions form Cooper pairs.

I have tried to understand also the amplitude windows but with no convincing results. The above model for the quantum currents however suggests a new approach to the problem. Since ELF em fields are in question they can be practically constant in the time scale of the dynamics involved. Suppose that the massless extremal representing ELF em field is orthogonal to the flux tube so that the ions flowing along flux tube experience an electric force parallel to flux tube. What would happen that the ions at the flux tube would topologically condensed at both the flux tube and massless extremal simultaneously and experience the sum of two forces.

This situation is very much analogous to that defined by magnetic flux tube with longitudinal electric field and also now quantum currents could set on. Suppose that semiconductor property means that ions must gain large enough energy in the electric field so that they can leak to a smaller space-time sheet and gain one metabolic quantum characterized by the p-adic length scale in question. If the electric field is above the critical value, the quantum current does not however reach the second capacitor plate as already found: classically this is of course very weird. If the

electric field is too weak, the energy gain is too small to allow the transfer of ions to smaller space-time sheet and no effect takes place. Hence one would have an amplitude window.

The amplitude window occur in widely separate ranges 1-10 V/m and around 10^{-7} V/m. Of course, also other ranges might be possible. Fractality and the notion of magnetic body suggests a possible explanation for the widely different frequency ranges. Both p-adic length scale hypothesis and the hierarchy of Planck constants suggest that some basic structures associated with the cell membrane have fractal counterparts in a wide length scale range and correspond to binary structures. Magnetic flux tubes carrying quantal DC currents of Becker would be the most natural candidate in this respect since these currents appear in several length scales inside organism. Also the counterparts of lipid layers of cell membrane could be involved. If so, one must include to the hierarchy of amplitude windows also fields in the range corresponding to the cell membrane resting potential of about 6×10^6 V/m. This is of course only a rough order of magnitude estimate since perturbations of these field are in order.

Fractality motivates some guess for voltage and electric field.

1. The voltage along the flux tube could be invariant under the scaling of Planck constant. The interpretation could be that the charges at the ends of the linear structure generate an electric flux running along the structure do not depend on the length L of the structure so that the electric field along linear structure behaves as $1/L \propto 1/h_{eff}$ as a function of the length scale $L \propto h_{eff}$ so that voltage between the ends does not depend on the length of the structure. This would give rise to a universal amplitude window for voltage rather than potential. The cell membrane electric field of 6×10^6 V/m would correspond to the field 6 mV/m. This kind of voltages could be associated with Becker's DC currents and the order of magnitude would be around few mV.

   Note that if the electric flux is like that between point charges, the scaling law $E \propto 1/h_{eff}^2$ holds true.

2. There could be also a constant electric field along microtubular structures due to polarization - most naturally tubulin polarization. This field strength serves as a candidate for a universal amplitude window for electric field.

   The idea that the direct currents of Becker run between lipid layers of cell does not conform with the hypothesis about generalized Josephson currents between them. There are electric fields along microtubules and one could wonder whether the DC voltages of Becker could relate to the voltages between the ends of linear structures formed by axonal and dendritic microtubules connected to each other by MAPs - single MT can have a length up to about 1 cm. The longitudinal electric field due to the dipole moments of tubulins and confined to tubulin structure does not depend on its length L, and the electric field of 1 mV/m would correspond 10^3 V/μm, which is by order of magnitude larger than the constant longitudinal dipole electric field of order 10^2 eV/μm generated by tubulin dipoles estimated to have strength 337 Debye in [I76] (note that MT has radius of $R = 25$ nm, thickness of $\Delta R = 4$ nm and length of $d = 8$ nm and the volume of MT fragment defined by 13 parallel tubulins is given by $V = 13 \times 2\pi R^2 \Delta R$ and that electric is $E = p/V$). If Becker's direct currents correspond to electric fields due to the charge difference between the ends of tubulins, one can consider the possibility that Becker's longitudinal electric fields have micro.tubular origin.

3. Electric field in the range $E = 1 - 10$ V/m assignable to EEG would correspond to field of $(1 - 10) \times 10^3$ V/μm and seems to be too large to be assigned with microscopic structures. DNA is a possible candidate since the smaller thickness of DNA would increase the dipole moment density by a factor of order 10^3 from that for MTs. The electric field of 10^{-7} eV/m seems to be associated with much larger structure than organism.

Effects of 50 Hz magnetic fields on living matter

The vision about the role of cyclotron Bose-Einstein condensates was inspired by the effects of ELF em fields on vertebrate brain. The magnetic field strength explaining the effects was about.2 Tesla, 2/5 of the nominal value for the strength of Earth's magnetic field.

There are also other experiments have demonstrated that oscillating electromagnetic fields have effects on living matter. In particle oscillatory magnetic fields with frequency of 50 Hz and

with field strengths typically in the range.1-1 mT are used: these effects are summartized in [J117]. Even fields of order.14 Tesla are used.

It is interesting to look at the values of basic parameters associated with these fields.

1. For 50 Hz oscillation frequency the wave length λ is 6000 km to be compared with the radius of Earth which is 6371 km. If one takes seriously the notion of magnetic body this need not be an accident. I do not know how essential it is to have just 50 Hz frequency. The magnetic field is nearby oscillating dipole field (see `http://tinyurl.com/36c4pfg`) up to distances of order λ and radiation field at much longer distances. Therefore the field in question is in good approximation nearby field as fart as biological body is considered. For magnetic body the radiation field could dominate

2. For the endogenous magnetic field $B_{end} = .2$ Gauss cyclotron frequencies of ions are in EEG range: Ca^{++} cyclotron frequency is 15 Hz. The scaling up to r=.1-1 mT means scaling of cyclotron frequencies by a factor $5 - 50$. For Ca^{++} this would give frequency range 75-750 Hz. For K^+ and Cl^+ ions the frequency range would be about 35-375 Hz.

3. The magnetic length $r = \sqrt{2/eB}$ characterizing flux tube thickness for flux quantization with minimum value of flux is for $B = .05$ mTesla equal to 5 μm. For the fields in the range .1-1 mTesla it is in the range 3.5 μm- 1.1 μm. 2.5 μm corresponds to p-adic length scales $L_e(k)$ associated with Gaussian Mersenne $M_{G,k} = (1 + i)^k - 1$, $k = 167$, and Gaussian Mersenne correspondng to $k = 163$ would correspond to p-adic length scale .36 μm. .14 Tesla corresponds to magnetic length of 9.4 nm rather near to cell membrane thickness of 10 nm which corresponds to p-adic length cale $L_e(151)$ assignable to Gaussian Mersenne $M_{G,151}$.

The effects of polarized light on living matter

Polarized light is known to have effects on living matter [J117]. For instance, Peter Gariaev has found that the polarized light generated by living matter sample irradiated by polarized laser light has effects on distant organism and there are even indications that genetic code might be realized in terms of radiation patterns [K127]. The quantum model for Becker currents suggest that these effects result as a modification of the voltage between the ends of magnetic flux tubes If the flux tubes are near criticality for the generation of quantal DC currents, polarized light could be utilized both communication and control purposes wheres the acceleration in the electric fields along flux tubes would serve as a provider of metabolic energy allowing to load metabolic batteries. This process could be initiated by an electromagnetic signal inducing generation of quantal currents. The same basic mechanism could be at work also in DNA transcription, replication and other similar processes.

If the polarized low frequency radiation corresponds to a massless extremal (ME) orthogonal to the flux tube such that the polarization of the radiation is parallel to the flux tube, the voltage is affected by a contribution given by $\Delta V = Ed$, d the thickness of ME. If the flux tube is near criticality to a generation of quantal currents this change of voltage could serve as a signal inducing the generation of quantal currents.

The maximal effect is obtained for the flux tubes having direction parallel to the electric polarization so that the effect is highly selective. In the case of DNA double strand the direction of flux tube changes so that the effect would be maximal on DNAs which correspond to the same angular position on the super-coil of radius of order 10 nm formed by DNA double helix. This allows to imagine signals for which temporal variation of polarization direction means scanning of DNA.

It is known that the energy of radiation can be transformed to metabolic energy. For instance, IR light for which photons have energies of order metabolic quantum has biological effects [I143]. The mechanism could be following. Suppose that the electric field of IR photon is parallel to the flux tube which carries an electric field and is near criticality for the generation of quantal DC currents. If the direction of polarization is correct, the additional contribution to electric field induces direct current and acceleration of electrons and protons and their transfer to smaller space-time sheets and therefore loading of metabolic batteries. This could also make generation of ATP possible.

Suppose that one takes seriously the model for remote replication of DNA [K127] involving flux tubes connecting identical DNA nucleotides and that the radiation propagating along them induces quantal currents along the receiving DNA inducing replication and perhaps even transcription. The direction of polarization for the emitted radiation should be parallel to the DNA strand locally and during its travel to the target the polarization should remain orthogonal to the flux tube so that one would have what might be called polarization window. Parallel translation of the polarization vector in the induced metric suggests itself.

Support for the proposed interaction mechanism of em radiation fields with flux tubes

The basic prediction of the interaction mechanism is that the effects of em field with a given frequency occur only at the second half period when the direction of electric field is "correct". This prediction might be testable. In fact, there is evidence for this interaction mechanism in the case of theta waves of EEG. The memory storage occurs only at the second half of the theta wave This is discussed from different point of view in [K5].

The place coding by phase shifts was discovered by O′Reefe and Recce [J106]. In [J126, J125]. Y. Yamaguchi describes the vision in which memory formation by so called theta phase coding is essential for the emergence of intelligence. It is known that hippocampal pyramidal cells have "place property" being activated at specific "place field" position defined by an environment consisting of recognizable objects serving as landmarks. The temporal change of the percept is accompanied by a sequence of place unit activities. The theta cells exhibit change in firing phase distributions relative to the theta rhythm and the relative phase with respect to theta phase gradually increases as the rat traverses the place field. In a cell population the temporal sequence is transformed into a phase shift sequence of firing spikes of individual cells within each theta cycle.

Thus a temporal sequence of percepts is transformed into a phase shift sequence of individual spikes of neurons within each theta cycle along linear array of neurons effectively representing time axis. Essentially a time compressed representation of the original events is created bringing in mind temporal hologram. Each event (object or activity in perceptive field) is represented by a firing of one particular neuron at time τ_n measured from the beginning of the theta cycle. τ_n is obtained by scaling down the real time value t_n of the event. Note that there is some upper bound for the total duration of memory if scaling factor is constant.

One can say that neurons in ensemble provide a representation for the external world and the location of the rodent in the external world is represented as a firing of a neuron in this landscape. Besides this also temporal scaling down by a factor about ten is carried out so that actual event is represented as much shorter copies of it. Obviously this represents temporal fractality.

This scaling down - story telling - seems to be a fundamental aspect of memory. Our memories can even abstract the entire life history to a handful of important events represented as a story lasting only few seconds. This scaling down is thought to be important not only for the representation of the contextual information but also for the memory storage in the hippocampus. Hierarchy of Planck constants and phase transitions changing Planck constant make this story building possible.

The finding of Yamaguchi and collaborators relevant in the recent context is that the gradual phase shift occurs at half theta cycle whereas firings at the other half cycle show no correlation [J126]. The proposed model for the interaction of theta waves with flux tubes could explain this naturally. The relevant neural sub-system would be critical to the generation of quantal DC current only when the direction electric field of synchronizing theta wave generated by magnetic body is correct. Hence synchronous neural activity would be induced only at second half cycle of theta wave and firing would be random during the other half cycle.

7.5.3   A Model For Remote Gene Expression Based On Becker Currents

If one accepts the notion of magnetic body as intentional agent, the basic challenge is to understand how magnetic body realizes its intents as remote mental interactions on biological body. This model must of course apply also to the more conventional remote mental interactions such as remote realization of intent.

The hypothesis is that electromagnetic and possibly also other massless classical fields assignable to so called massless extremals are in a key role. Also cyclotron frequencies characteriz-

ing magnetic bodies play a key role. The vision is that magnetic flux sheets traverse many-sheeted DNA in various scales giving rise to a hierarchy of genomes and coherent gene expression in scales of cell, organelles, organism, and even population, and species. Hierarchy of Planck constants is in an essential role in realizing this hierarchy in terms of photons with energies above the thermal energy at physiological temperature and having spectrum of wavelengths coming as multiples $\lambda = n\lambda_0$, $n = \hbar/\hbar_0$.

The findings of Benveniste and followers relating to water memory and homeopathy, the recent work of group led by HIV Nobelist Luc Montagnier coupling the findings with genetics and suggesting a new nanoscale realization of genetic code [L6]), the work of the group of Popp with bio-photons identified as decay produces of large $\hbar$ photons with visible energies (in particular dark EEG photons), and the work of Peter Gariaev and collaborators supporting remote gene expression and replication discussed [K127] suggest that electromagnetic radiation is indeed involved. In the case of water memory and homeopathy the spectrum of cyclotron frequencies for the chemical invader characterizes it and induces immune response trying to eliminate it. I have also proposed a model for how genes coding for proteins eliminating the invader could be generated almost automatically: the model is based on the predicted realization of vertebrate genetic code in terms of dark proton states [K53]. DNA would like an animal which sniffs the invaders magnetic body and automatically reacts to the smell.

The discussions with Lian Sidorov and people who have realized that new era is beginning in biology have served as a driving force in the attempts to formulate in more detail TGD inspired view about how remote mental interactions - which are basic element of the model in TGD framework - might be realized. As a matter fact, I have added to my homepage a new book summarizing briefly the recent view about quantum TGD and its applications to quantum consciousness, quantum biology, to quantum neuroscience, and to remote mental interactions with some proposals for possible tests [K112]).

To start with, suppose that in the case of biological target realization of intent in the simplest situation reduces to expression of genes. This is of course a strong limitation to the type of remote mental interactions. The challenge is to develop a model for remote realization of genetic activities like replication, and transcription. For some time ago I proposed a model with Peter Gariaev [K127] but it was still too clumsy since it required too much of information transfer between the genomes of sender and receiver. Much simpler model involving only sending of simple commands initiating genetic programs suggests itself. The following proposal tries to achieve this and involves three basic ideas.

1. The idea of password and addressing is familiar from ordinary computers. Collection of frequencies as password/address allows to reach tuned targets without specific targeting of the command. This is a dramatic improvement to the previous model.

2. Password and fractal addressing realized in terms of frequencies coupling resonantly (already in the original model: I did not however realize the implications of resonant coupling!) and the hierarchy of Planck constants to realize the hierarchical addressing. I have discussed analogous addressing based on information molecules and their receptors at the biochemical level to realize magnetic flux tube connections between sender and target inside organism (hormonal action would be very analogous to what I am proposing here).

3. Becker's DC currents as supra currents flowing along DNA and activated optimally when the incoming laser light has polarization parallel to DNA's local direction, activation of super currents would mean activation of the gene. This is second new element to the original model.

In the following I discuss this with more details.

The analogy with ordinary computer

Consider first the analog of remote mental interactions for ordinary computer. Computer sends a password to the other computer and after that it can use it to run programs of the other computer. Whisling to a dog is another example: extremely simple command activates arbitrary complex programs.

In the recent case electromagnetic radiation with a given frequency coupling resonantly like radio signal to a tuned radio receiver would be the simplest command activating the target. There

would no need to specify the direction or distance of the target precisely since essentially mass communications would be in question: intent would be enough. Password could consist of several frequencies which must be received simultaneously by the target before it would activate and tunes to receive more frequencies representing simple commands - perhaps acting on the intronic portion of DNA and activating the genome to remote gene expression or something else such as activating DNAs of other cells by sending similar em addresses!

I have discussed topological quantum computer programs (see `http://tinyurl.com/y84g3tk7`) based on braiding could look like in this framework [L11]. Also here addressing but now realized as information molecule-receptor pair would play a key role.

Hierarchy of Planck constants and hierarchical addressing

Fractal hierarchy of frequencies (in Peter's experiment laser light induced generation of radiation at frequencies down to about 10 kHz) would allow to transform passwording to addressing. Very naïvely, the longest wavelengths: about 10^4 meters would reach the tuned receivers in nearly the same phase in a region of this size. One would have some subregions in tune. The shorter wavelengths would allow to pinpoint the tuned receivers inside each of these subregions and so on. This would be fractal addressing with most significant bits correspond to the longest wavelengths. Only those receivers which would be tuned to all frequencies would start to express the gene in the case of AND logic. Of course, also other Boolean functions of tuned-not tuned bits can be considered.

A good guess is that all photons correspond to the same energy of visible photon and only Planck constant varies. For ordinary value of Planck constant one would have a photon with wavelength of order size scale of single cell, and the frequencies in this range would select single gene in the genome ofa particular kind of cell, say neuron within particular region of brain.

In Peter Gariaev's experiment involving 2 eV incoming red laser light the outgoing photons would have same energy but larger Planck constant so that also wavelengths would be longer and range down to at least 3×10^4 meters corresponding to radiofrequency scale of 10 kHz. What is interesting that 2 eV is 4 times the nominal value of the metabolic energy quantum of .5 eV identifiable as zero point kinetic energy of electron or proton for the p-adic length scale $L_e(151)$ corresponding to cell membrane thickness and Gaussian Mersenne $M_{151} = (1 + i)^{151} - 1$. Could it be that 2 eV could be preferred photon energy or is its use simply due to the unavailability of continuous frequency spectrum for laser light. And why the laser light induces the generation of the command inducing remote gene expression?

This picture conforms with Peter's experiment and with the reports of Benveniste and followers about the possibility of representing homeopathic remedy using very low frequency spectrum - presumably cyclotron frequencies - assignable to remedy. These frequencies would be addresses for genes activating genes transcribing building bricks of biomolecules of immune response eliminating the substance from the organism. The proposal could be seen as a generalization of Benveniste's observation and realization of wave DNA proposal.

DNA supra currents and activation of genes by Becker mechanism

The third bulding brick of the model would be quantum model for Becker currents (see `http://tinyurl.com/ybnjk9bq`) [L12] as supra currents or quantal DC currents: also this element is new. Assume - in accordance with the general vision - that these supra currents can flow also along the strands of many-sheeted DNA (flux sheets associated with the strand, entire hierarchy labelled by the values of $\hbar$). Assume also that the interaction of polarized photons addressing for genes with DNA is such that the electric fields of DNA flux tube and "massless extremal" representing laser beam superpose and charges (electrons) experience the superposition of field already present and the field of ME. If the net electric field is near criticality originally (think as analog neuronal membrane) and becomes over-critical, quantal Becker current starts to flow and the machinery responsible for gene activation is activated.

This means also the activation of metabolic machinery since the acceleration of electrons in the electric field gives them energy making possible a transfer to smaller space-time sheets where they form Cooper pair like states with negentropic entanglement. Metabolic energy corresponds to zero point kinetic energy and negentropic entanglement is relevant from the point of view

of consciousness: in the case of healing understood as a regeneration of negentropic resources this aspect is especially important. This mechanism generates high energy phosphate bonds in ATP and the decay ATP → ADP liberates the metabolic energy and destroys the negentropic entanglement possibly associated with ATP so that the second law in generalized form (see `http://tinyurl.com/yakmqhz6`) [L8] allowing local generation of genuine negentropy (but assigned to information carried by entanglement defining a quantum rule) wins after all.

It could also happen that the decay of ATP generates dark photon or photons absorbed by cyclotron condensate at magnetic flux tube. The excited state is non-local single particle excitation and involves very simple negentropic entanglement between the particles of the condensate. In this case the negentropy of ATP would be transformed to the negentropy of the magnetic flux tube or even several of them if large value of Planck constant is associated with the photon. This mechanism could allow the generation of negentropic entanglement associated with attention. The storage of metabolic energy in photosynthesis could involve similar excitation of cyclotron state at the first step. The most plausible candidate is cyclotron condensate for electron Cooper pairs. Also electrons filling state up to some Fermi energy could be in question. In this case the excitations would be excitation in longitudinal degrees of freedom of the flux tube generating current.

7.6 Could Cell Membrane Correspond To Almost Vacuum Extremal?

The question whether cell membrane or even cell could correspond almost vacuum extremal of Kähler action (in some cases) was the question which led to the realization that the frequencies of peak sensitivity for photoreceptors correspond to the Josephson frequencies of biologically important ions if one accepts that the value of the Weinberg angle equals to $sin^2(\theta_W) = .0295$ instead of the value .23 in the normal phase, in which the classical electromagnetic field is proportional to the induced Kähler form of CP_2 in a good approximation. Another implication made possible by the large value of Planck constant is the identification of Josephson photons as the counterparts of bio-photons one one hand and those of EEG photons on the other hand. These observation in turn led to a detailed model of sensory qualia and of sensory receptor. Therefore the core of this argument deserves to be represented also here although it has been discussed in [K92].

7.6.1 Cell Membrane As Almost Vacuum Extremal

Although the fundamental role of vacuum extremals for quantum criticality and life has been obvious from the beginning, it took a long time to realize how one could model living cell as this kind of system.

1. Classical electric fields are in a fundamental role in biochemistry and living biosystems are typically electrets containing regions of spontaneous electric polarization. Fröhlich [J80] proposed that oriented electric dipoles form macroscopic quantum systems with polarization density serving as a macroscopic order parameter. Several theories of consciousness share this hypothesis. Experimentally this hypothesis has not been verified.

2. TGD suggests much more profound role for the unique di-electric properties of the biosystems. The presence of strong electric dipole fields is a necessary prerequisite for cognition and life and could even force the emergence of life. Strong electric fields imply also the presence of the charged wormhole BE condensates: the surface density of the charged wormholes on the boundary is essentially equal to the normal component of the electric field so that wormholes are in some sense "square root" of the dipole condensate of Fröhlich! Wormholes make also possible pure vacuum polarization type dipole fields: in this case the magnitudes of the em field at the two space-time sheets involved are same whereas the directions of the fields are opposite. The splitting of wormhole contacts creates fermion pairs which might be interpreted as cognitive fermion pairs. Also microtubules carry strong longitudinal electric fields. This formulation emerged much before the identification of ordinary gauge bosons and their superpartners as wormhole contacts.

Cell membrane is the basic example about electret and one of the basic mysteries of cell biology is the resting potential of the living cell. Living cell membranes carry huge electric fields: something like 10^7 Volts per meter. For neuron resting potential corresponds to about.07 eV energy gained when unit charge travels through the membrane potential. In TGD framework it is not at all clear whether the presence of strong electromagnetic field necessitates the presence of strong Kähler field. The extremely strong electric field associated with the cell membrane is not easily understood in Maxwell's theory and almost vacuum extremal property could change the situation completely in TGD framework.

1. The configuration could be a small deformation of vacuum extremal so that the system would be highly critical as one indeed expects on basis of the general visiona about living matter as a quantum critical system. For vacuum extremals classical em and Z^0 fields would be proportional to each other. The second half of Maxwell's equations is not in general satisfied in TGD Universe and one cannot exclude the presence of vacuum charge densities in which case elementary particles as the sources of the field would not be necessarily. If one assumes that this is the case approximately, the presence of Z^0 charges creating the classical Z^0 fields is implied. Neutrinos are the most candidates for the carrier of Z^0 charge. Also nuclei could feed their weak gauge fluxes to almost non-vacuum extremals but not atomic electrons since this would lead to dramatic deviations from atomic physics. This would mean that weak bosons would be light in this phase and also Weinberg angle could have a non-standard value.

2. There are also space-time surfaces for CP_2 projection belongs to homologically non-trivial geodesic sphere. In this case classical Z^0 field can vanish [L2], [L2] and the vision has been that it is sensible to speak about two basic configurations.

   (a) Almost vacuum extremals (homologically trivial geodesic sphere).
   (b) Small deformations of non-vacuum extremals for which the gauge field has pure gauge Z^0 component (homologically non-trivial geodesic sphere).

   The latter space-time surfaces are excellent candidates for configurations identifiable as TGD counterparts of standard electroweak physics. Note however that the charged part of electroweak fields is present for them.

3. To see whether the latter configurations are really possible one must understand how the gauge fields are affected in the color rotation.

   (a) The action of color rotations in the holonomy algebra of CP_2 is non-trivial and corresponds to the action in $U(2)$ sub-group of $SU(3)$ mapped to $SU(2)_L \times U(1)$. Since the induced color gauge field is proportional to Kähler form, the holonomy is necessary Abelian so that also the representation of color rotations as a sub-group of electro-weak group must correspond to a local $U(1)$ sub-group local with respect to CP_2 point.

   (b) Kähler form remains certainly invariant under color group and the right handed part of Z^0 field reducing to $U(1)_R$ sub-algebra should experience a mere Abelian gauge transformation. Also the left handed part of weak fields should experience a local $U(1)_L$ gauge rotation acting on the neutral left handed part of Z^0 in the same manner as it acts on the right handed part. This is true if the $U(1)_L$ sub-group does not depend on point of CP_2 and corresponds to Z^0 charge. If only Z^0 part of the induced gauge field is non-vanishing as it can be for vacuum extremals then color rotations cannot change the situation. If Z^0 part vanishes and non-vacuum extremal is in question, then color rotation rotation of W components mixing them but acts as a pure $U(1)$ gauge transformation on the left handed component.

   (c) It might not be without importance that for any partonic 2-surface induced electro-weak gauge fields have always U(1) holonomy, which could allow to define what neutral part of induced electroweak gauge field means locally. This does not however hold true for the 4-D tangent space distribution. In any case, the cautious conclusion is that there are two phases corresponding to nearly vacuum extremals and small deformations of extremals corresponding to homologically non-trivial geodesic spheres for which the neutral part of the classical electro-weak gauge field reduces to photon field.

4. The unavoidable presence of long range Z^0 fields would explain large parity breaking in living matter, and the fact that neutrino Compton length is of the order of cell size would suggest the possibility that within neutrino Compton electro-weak gauge fields or even longer scales could behave like massless fields. The explanation would be in terms of the different ground state characterized also by a different value of Weinberg angle. For instance, of the p-adic temperature of weak bosons corresponds to $T_p = 1/2$, the mass scale would be multiplied by a factor $\sqrt{M_{89}}$ and Compton lengths of weak bosons would be around 10^{-4} meters corresponding to the size scale of a large neuron. If the value of Planck constant is also large then the Compton length increases to astrophysical scale.

5. From the equations for classical induced gauge fields in terms of Kähler form and classical Z^0 field [L2] , [L2]

$$\gamma = 3J - \tfrac{p}{2}Z^0 \;\; , \;\; Q_Z = I_L^3 - pQ_{em} \;\; , \;\; p = sin^2(\theta_W) \tag{7.6.1}$$

it follows that for the vacuum extremals the part of the classical electro-weak force proportional to the electromagnetic charge vanishes for $p = 0$ so that only the left-handed couplings to the weak gauge bosons remain. The absence of electroweak symmetry breaking and vanishing or at least smallness of p would make sense below the Compton length of dark weak bosons. If this picture makes sense it has also implications for astrophysics and cosmology since small deformations of vacuum extremals are assumed to define the interesting extremals. Dark matter hierarchy might explain the presence of unavoidable long ranged Z^0 fields as being due to dark matter with arbitrarily large values of Planck constant so that various elementary particle Compton lengths are very long.

6. The simplest option is that the dark matter -say quarks with Compton lengths of order cell size and Planck constant of order $10^7\hbar_0$ - are responsible for dark weak fields making almost vacuum extremal property possible. The condition that Josephson photons correspond to EEG frequencies implys $\hbar \sim 10^{13}\hbar_0$ and would mean the scaling of intermediate gauge boson Compton length to that corresponding to the size scale of a larger neuron. The quarks involved with with DNA as topological quantum computer model could be in question and membrane potential might be assignable to the magnetic flux tubes. The ordinary ionic currents through cell membrane -having no coupling to classical Z^0 fields and not acting as its sourse- would be accompanied by compensating currents of dark fermions taking care that the almost vacuum extremal property is preserved. The outcome would be large parity breaking effects in cell scale from the left handed couplings of dark quarks and leptons to the classical Z^0 field. The flow of Na^+ ions during nerve pulse could take along same dark flux tube as the flow of dark quarks and leptons. This near vacuum extremal property might be fundamental property of living matter at dark space-time sheets at least.

Could nuclei and neutrinos couple to light variants of weak gauge fields in the critical phase?

One of the hard-to-kill ideas of quantum TGD inspired model of quantum biology is that neutrinos might have something do with hearing and cognition. This proposal looks however unrealistic in the recent vision. I would be more than happy to get rid of bio-neutrinos but the following intriguing finding does not allow me to have this luxury.

1. Assume that the endogenous magnetic field $B_{end} = .2$ Gauss is associated with a nearly vacuum extremal and therefore accompanied by $B_Z = 2B_{end}/p$. Assume for definiteness $m_\nu = .3$ eV and $p = sin^2(\theta_W) = .23$. The neutrino cyclotron frequency is given by the following expression

$$f_\nu = \frac{m_e}{m_\nu}\frac{1}{2sin^2(\theta_W)}f_e \;\; .$$

From $f_e \simeq .57\times$ MHz and $p = sin^2(\theta_W) = .23$ one obtains $E_\nu = 1.7 \times 10^{-2}$ eV, which is roughly one third to the Josephson frequency of electron assignable to cell membrane. Could Josephson frequency of cell membrane excite neutrino cyclotron transitions?

2. The model for photoreceptors to be discussed below forces to conlude that the value of Weinberg angle in the phase near vacuum extremal must be $p = .0295$ if one wants to reproduces the peak energies of photoreceptors as Josephson frequencies of basic biological ions. This would predict $E_\nu = .41$ eV, which is rather near to the metabolic energy quantum. The non-relativistic formula however fails in this case and one must use the relativistic formula giving

$$E = \sqrt{g_Z Q_Z B_Z 2\pi} \simeq .48 \ eV$$

giving the metabolic energy quantum. Does this mean that Z^0 cyclotron frequency for neutrino is related to the transfer of metabolic energy using Z^0 MEs in the phase near vacuum extremals.

3. Josephson frequency is proportional to $1/\hbar$, whereas neutrino cyclotron frequency does not depend on $\hbar$ at non-relativistic energies. For larger values of $\hbar$ the neutrino becomes relativistic so that the mass in the formula for cyclotron frequency must be replaced with energy. This gives

$$E = \sqrt{n} r^{1/2} \sqrt{g_Z Q_Z B_Z 2\pi} \simeq r^{1/2} \times .48 \ eV \ , \ r = \sqrt{\hbar/\hbar_0} \ .$$

Here n refers to the cyclotron harmonic.

These observations raise the question whether the three frequencies with maximum response assignable to the three different types of receptors of visible light in retina could correspond to the three cyclotron frequencies assignable to the three neutrinos with different mass scales? The first objection is that the dependence on mass disappears completely at the relativistic limit. The second objection is that the required value value of Planck constant is rather small and far from being enough to have electroweak boson Compton length of order cell size. One can of course ask whether the electroweak gauge bosons are actually massless inside almost vacuum extremals. If fermions -including neutrino- receive their masses from p-adic thermodynamics then massless electroweak gauge bosons would be consistent with massive fermions. Vacuum extremals are indeed analogous to the unstable extrema of Higgs potential at which the Higgs vacuum expecation vanishes so that this interpretation might make sense.

Ionic Josephson frequencies defined by the resting potential for nearly vacuum extremals

If cell membrane corresponds to an almost vacuum extremal, the membrane potential potential is replaced with an effective resting potential containing also the Z^0 contribution proportional to the ordinary resting potential. The surprising outcome is that one could understand the preferred frequencies for photo-receptors [J12] as Josephson frequencies for biologically important ions. Furthermore, most Josephson energies are in visible and UV range and the interpretation in terms of bio-photons is suggestive. If the value of Planck constant is large enough Josephson frequencies are in EEG frequency range so that bio-photons and EEG photons could be both related to Josephson photons with large $\hbar$.

1. One must assume that the interior of the cell corresponds to many fermion state -either a state filled with neutrinos up to Fermi energy or Bose-Einstein condensate of neutrino Cooper pairs creating a harmonic oscillator potential. The generalization of nuclear harmonic oscillator model so that it applies to multi-neutrino state looks natural.

2. For exact vacuum extremals elementary fermions couple only via left-handed isospin to the classical Z^0 field whereas the coupling to classical em field vanishes. Both K_+, Na_+, and Cl_- $A - Z = Z + 1$ so that by p-n pairing inside nucleus they have the weak isospin of neutron (opposite to that of neutrino) whereas Ca_{++} nucleus has a vanishing weak isospin. This might relate to the very special role of Ca_{++} ions in biology. For instance, Ca_{++} defines

$E(Ion)/eV$	$V = -40\ mV$	$V = -60\ mV$	$V = -70\ mV$
Na^+	1.01	1.51	1.76
Cl^-	1.40	2.11	2.46
K^+	1.64	2.47	2.88
Ca^{++}	1.68	2.52	2.94

Table 7.1: Values of the Josephson energy of cell membrane for some values of the membrane voltage for $p = .23$. The value $V = -40$ mV corresponds to the resting potential for photoreceptors and $V = -70$ mV to the resting state of a typical neuron.

an action potential lasting a time of order.1 seconds whereas Na_+ defines a pulse lasting for about 1 millisecond [J3]. These time scales might relate to the time scales of CDs associated with quarks and electron.

3. The basic question is whether only nuclei couple to the classical Z^0 field or whether also electrons do so. If not, then nuclei have a large effective vector coupling to em field coming from Z^0 coupling proportional to the nuclear charge increasing the value of effective membrane potential by a factor of order 100. If both electrons and nuclei couple to the classical Z^0 field, one ends up with difficulties with atomic physics. If only quarks couple to the Z^0 field and one has $Z^0 = -2\gamma/p$ for vacuum extremals, and one uses average vectorial coupling $\langle I_L^3 \rangle = \pm 1/4$ with + for proton and - for neutron, the resulting vector coupling is following

$$
\begin{aligned}
\left(\frac{Z-N}{4} - pZ\right)Z^0 + q_{em}\gamma &= Q_{eff}\gamma \ , \\
Q_{eff} &= -\frac{Z-N}{2p} + 2Z + q_{em} \ .
\end{aligned}
\tag{7.6.2}
$$

Here γ denotes em gauge potential. For K^+, Cl^-, Na^+, Ca^{++} one has $Z = (19, 17, 11, 20)$, $Z - N = (-1, -1, -1, 0)$, and $q_{em} = (1, -1, 1, 2)$. **Table 9.1** below gives the values of Josephson energies for some values of resting potential for $p = .23$. Rather remarkably, they are in IR or visible range. This is basically due to the large value of weak isospin for nuclei.

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7.6.2 Are Photoreceptors Nearly Vacuum Extremals?

In Hodgkin-Huxley model ionic currents are Ohmian currents. If one accepts the idea that the cell membrane acts as a Josephson junction, there are also non-dissipative oscillatory Josephson currents of ions present, which run also during flow equilibrium for the ionic parts of the currents. A more radical possibility is that the dominating parts of the ionic currents are oscillatory Josephson currents so that no metabolic energy would be needed to take care that density gradients for ions are preserved. Also in this case both nearly vacuum extremals and extremals with nearly vanishing Z^0 field can be considered. Since sensory receptors must be highly critical the natural question is whether they could correspond to nearly vacuum extremals. The quantitative success of the following model for photoreceptors supports this idea.

Photoreceptors can be classified to three kinds of cones responsible for color vision and rods responsible for black-white vision. The peak sensitivities of cones correspond to wavelengths (405, 535, 565) nm and energies (3.06, 2.32, 2.19) eV. The maximum absorption occurs in the wave length range 420-440 nm, 534-545 nm, 564-580 nm for cones responsible for color vision and 498 nm for rods responsible black-white vision [L59, J12]. The corresponding photon energies are (2.95, 2.32, 2.20) eV for color vision and to 2.49 eV for black-white vision. For frequency distribution the maxima are shifted from these since the maximum condition becomes $dI/d\lambda + 2I/\lambda = 0$, which means a shift to a larger value of λ, which is largest for smallest λ. Hence the energies for maximum absorbance are actually lower and the downwards shift is largest for the highest energy.

From **Table 9.1** it is clear that the energies of Josephson photons are in visible range for reasonable values of membrane voltages, which raises the question whether Josephson currents of nuclei in the classical em and Z^0 fields of the cell membrane could relate to vision.

Consider first the construction of the model.

1. Na^+ and Ca^{++} currents are known to present during the activation of the photoreceptors. Na^+ current defines the so called dark current [J12] reducing the membrane resting potential below its normal value and might relate to the sensation of darkness as eyes are closed. Hodgkin-Huxley model predicts that also K^+ current is present. Therefore the Josephson energies of these three ion currents are the most plausible correlates for the three colors.

2. One ends up with the model in the following manner. For Ca^{++} the Josephson frequency does not depend on p and requiring that this energy corresponds to the energy 2.32 eV of maximal sensitivity for cones sensitive to green light fixes the value of the membrane potential during hyper-polarization to $V = .055$ V, which is quite reasonable value. The value of the Weinberg angle parameter can be fixed from the condition that other peak energies are reproduced optimally. The result of $p = .0295$.

The predictions of the model come as follows summarized also by the **Table 9.2**.

1. The resting potential for photoreceptors is $V = -40$ mV [J15]. In this case all Josephson energies are below the range of visible frequencies for $p = .23$. Also for maximal hyper-polarization Na^+ Josephson energy is below the visible range for this value of Weinberg angle.

2. For $V = -40$ mV and $p = .0295$ required by the model the energies of Cl^- and K^+ Josephson photons correspond to red light. 2 eV for Cl^- corresponds to a basic metabolic quantum. For Na^+ and Ca^{++} the wave length is below the visible range. Na^+ Josephson energy is below visible range. This conforms with the interpretation of Na^+ current as a counterpart for the sensation of darkness.

3. For $V = -55$ mV - the threshold for the nerve pulse generation- and for $p = .0295$ the Josephson energies of Na^+, Ca^{++}, and K^+ a correspond to the peak energies for cones sensitive to red, green, and blue respectively. Also Cl^- is in the blue region. Ca^{++} Josephson energy can be identified as the peak energy for rods. The increase of the hyper-polarization to $V = -59$ mV reproduces the energy of the maximal wave length response exactly. A possible interpretation is that around the criticality for the generation of the action potential ($V \simeq -55$ mV) the qualia would be generated most intensely since the Josephson currents would be strongest and induce Josephson radiation inducing the quale in other neurons of the visual pathway at the verge for the generation of action potential. This supports the earlier idea that visual pathways defines a neural window. Josephson radiation could be interpreted as giving rise to bio-photons (energy scale is correct) and to EEG photons (for large enough values of $\hbar$ the frequency scales is that of EEG).

4. In a very bright illumination the hyper-polarization is $V = -65$ mV [J15], which the normal value of resting potential. For this voltage Josephson energies are predicted to be in UV region except in case of Ca^{++}. This would suggests that only the quale "white" is generated at the level of sensory receptor: very intense light is indeed experienced as white.

The model reproduces basic facts about vision assuming that one accepts the small value of Weinberg angle, which is indeed a natural assumption since vacuum extremals are analogous to the unstable extrema of Higgs potential and should correspond to small Weinberg angle. It deserves to be noticed that neutrino Josephson energy is 2 eV for $V = -50$ mV, which correspond to color red. 2 eV energy defines an important metabolic quantum.

It interesting to try to interpret the resting potentials of various cells in this framework in terms of the Josephson frequencies of various ions.

Ion	Na^+	Cl^-	K^+	Ca^{++}
$E_J(.04\ mV, p = .23)/eV$	1.01	1.40	1.51	1.76
$E_J(.065\ V, p = .23)/eV$	1.64	2.29	2.69	2.73
$E_J(40\ mV, p = .0295)/eV$	1.60	2.00	2.23	1.68
$E_J(50\ mV, p = .0295)/eV$	2.00	2.49	2.79	2.10
$E_J(55\ mV, p = .0295)/eV$	2.20	2.74	3.07	2.31
$E_J(65\ mV, p = .0295)/eV$	2.60	3.25	3.64	2.73
$E_J(70\ mV, p = .0295)/eV$	2.80	3.50	3.92	2.94
$E_J(75\ mV, p = .0295)/eV$	3.00	3.75	4.20	3.15
$E_J(80\ mV, p = .0295)/eV$	3.20	4.00	4.48	3.36
$E_J(90\ mV, p = .0295)/eV$	3.60	4.50	5.04	3.78
$E_J(95\ mV, p = .0295)/eV$	3.80	4.75	5.32	3.99
Color	R	G	B	W
E_{max}	2.19	2.32	3.06	2.49
energy-interval/eV	1.77-2.48	1.97-2.76	2.48-3.10	

Table 7.2: Table gives the prediction of the model of photoreceptor for the Josephson energies for typical values of the membrane potential. For comparison purposes the energies E_{max} corresponding to peak sensitivities of rods and cones, and absorption ranges for rods are also given. R, G, B, W refers to red, green, blue, white. The values of Weinberg angle parameter $p = sin^2(\theta_W)$ are assumed to be .23 and .0295. The latter value is forced by the fit of Josephson energies to the known peak energies if one allows that ions - rather than their Cooper pairs - are charge carriers.

1. The maximum value of the action potential is +40 mV so that Josephson frequencies are same as for the resting state of photoreceptor. Note that the time scale for nerve pulse is so slow as compared to the frequency of visible photons that one can consider that the neuronal membrane is in a state analogous to that of a photoreceptor.

2. For neurons the value of the resting potential is -70 mV. Na^+ and Ca^{++} Josephson energies 2.80 eV and 2.94 eV are in the visible range in this case and correspond to blue light. This does not mean that Ca^{++} Josephson currents are present and generate sensation of blue at neuronal level: the quale possibly generated should depend on sensory pathway. During the hyper-polarization period with -75 mV the situation is not considerably different.

3. The value of the resting potential is -95 mV for skeletal muscle cells. In this case Ca^{++} Josephson frequency corresponds to 4 eV metabolic energy quantum as **Table 9.1** shows.

4. For smooth muscle cells the value of resting potential is -50 mV. In this case Na^+ Josephson frequency corresponds to 2 eV metabolic energy quantum.

5. For astroglia the value of the resting potential is -80/-90 mV for astroglia. For -80 mV the resting potential for Cl^- corresponds to 4 eV metabolic energy quantum. This suggests that glial cells could also provide metabolic energy as Josephson radiation to neurons.

6. For all other neurons except photo-receptors and red blood cells Josephson photons are in visible and UV range and the natural interpretation would be as bio-photons. The bio-photons detected outside body could represent sensory leakage. An interesting question is whether the IR Josephson frequencies could make possible some kind of IR vision.

To sum up, the basic criticism against the model is that the value of Weinberg angle must be by a factor of 1/10 smaller than the standard model value, and at this moment it is difficult to say anything about its value for nearly vacuum extremals.

A possible cure could be that the voltage is not same for different ions. This is possible since at microscopic level the Josephson junctions correspond to transmembrane proteins acting as channels and pumps. The membrane potential through receptor protein is different for color receptors. For this option one would have the correspondences

$Na^+ \leftrightarrow 2.19$ eV (R) and $eV = 86.8$ eV,
$Cl^- \leftrightarrow 2.32$ eV (G) and $eV = 65.8$ eV,
$K^+ \leftrightarrow 2.49$ eV (W) and $eV = 60.2$ eV,
$Ca^{++} \leftrightarrow 3.06$ eV (B) and $eV = 67.3$ meV.
For Na^+ the value of the membrane potential is suspiciously large.

It is interesting to look what happens when the model is generalized so that Josephson energy includes the difference of cyclotron energies at the two sides of the cell membrane and Weinberg angle has its standard model value.

1. Consider first *near to vacuum extremals*. In the formula for cyclotron frequencies in the effective magnetic field the factor Z/A in the formula of is replaced with

$$\frac{\frac{N-Z}{2p} + 2Z + q_{em}}{A} \ ,$$

   which is not far from unity so that the cyclotron frequency would be near to that for proton for all ions. Also neutral atoms would experience classical and magnetic Z^0 fields. Cyclotron frequency would be almost particle independent so that cyclotron contribution gives an almost constant shift to the generalized Josephson energy. When the difference of cyclotron energies vanishes, the model reduces to that discussed above.

   The weak independence of the cyclotron frequency on particle properties does not conform with the idea that EEG bands correspond to bosonic ions or Cooper pairs of fermionic ions.

2. For *far from vacuum extremals* the proportionality of cyclotron energy to h_{eff} and B_{end} allows easy reproduction the energies for which photon absorption is maximal if one allows the cyclotron energies to differ at the two sides of the membrane for sensory receptors.

A remark about decade later: The model just discussed neglects the fact that superconductivity requires that Cooper pairs of fermionic ions are present unless one assumes that the nuclei are bosonic counterparts of fermionic nuclei with same chemical properties - TGD inspired nuclear physics indeed predicts this kind of exotic nuclei [L3]. For Cooper pairs of Na^+, Cl^-, and K^+, $p = .23$ and $E_J = .04$ eV assignable to visual receptors the Josephson energies are doubled being $2.02, 2.80, 3.02$ eV. These energies could correspond to peak energies for visible photons. The assumption of ionic Cooper pairs is rather attractive since it would allow to avoid two questionable assumptions.

For electron the Josephson energy would be scaled by a factor $-1 + 1/2p$ to $E_J = 1.0859 \times eV_{rest}$ for $p = .2397$. For neutrino the energy would be given by $E_J = -0.0859 \times V_{rest}$: for $p = 1/4$ it would vanish by the vanishing of vectorial part of Z^0 charge. For proton the energy would be $E_J = (3 - 1/2p)V_{rest} = .914 \times V_{rest}$ and for neutron $E_J = V_{rest}/2p = 2.086 \times V_{rest}$.

7.6.3 Water Electric As Protocell

Ulla Matfolk sent to me some interesting material at the web page of Dr. Mae-Wan Ho which provides further insights into the model of cell. The articles are "Water electric" [D64] and "Making Fuel from Water" [D62]. The articles summarize an experimental discovery which could be called Pollack-Zheng effect [D72, D66]. Both articles relate closely to what might be called the holy grail of artificial photosynthesis. The unreasonable effectiveness of photosynthesis in the sense that the waste of energy during the process is extremely small, makes artificial photosynthesis an excellent candidate for the final solution of energy problems as far energy sources and minimization of wastes are considered. In the following I comment only the first paper in detail from TGD viewpoint.

How photosynthesis manages to be so effective is one of the mysteries of biology. TGD based view about metabolic energy involves two ideas.

1. TGD predicts a hierarchy of metabolic energy quanta [K17, K57]. The basic quanta come as $E(k) = 2^k E_0$, where k is positive or negative integer and $E_0 \simeq .5$ eV holds true. For instance, 2 eV metabolic energy quantum corresponding to red light corresponds to $k = 3$. This is actually oversimplification since there is a cascade of quanta $E(k, n) = (1 - 2 < sup > -n < /sup >)E(k)$ converging to $E(k)$ for each p-adic length scale. These energies correspond to

energies liberated when electron or proton drops to a larger space-time sheet at the limit when second space-time becomes very large and the particle starts from rest and remains to rest: this is second idealization as also the particle in a box geometry. The idea is that these universal metabolic energy quanta preceded the metabolism based on chemical storage of energy and that the primary step in photosynthesis is kicking of proton or electron to a smaller space-time sheet.

2. Second idea relies on the hierarchy of Planck constants.

   (a) The rate of dissipation - that this the energy wasted per unit time - is inversely proportional to $\hbar$ in the first naïve guess and means that macroscopically quantum coherent dark matter dissipates very little. Could photon kick charged dark particles to smaller space-time sheet where they dissipate very little? Or could photosynthesis capture ordinary or dark photons of sunlight to some layer of the onion like structure formed by the magnetic body of the organism, where it kicks particles to smaller space-time sheets. This light could correspond to bio-photons liberated as the biological body of the organism dies.

   (b) Could this storage of photons have preceded chemical storage of energy in living matter? And could this energy reserve explain some rather mysterious findings about the ability of some people to survive without ordinary metabolic energy feed (usually saints and this kind of people telling that light is enough for them to survive. Also animals are capable to these metabolic miracles [I43] : see the article "Researchers Seek to Demystify the Metabolic Magic of Sled Dogs" in Science. Of course, the storage of energy to that of dark matter or dark photons confined to the net defined by magnetic flux tubes could be the eventual manner to avoid energy waste and associated entropy growth inducing environmental problems. Hierarchy of Planck constants would allow the storage in arbitrary long length scales for given energy of photon so that even a community of organisms could have collective metabolic energy resources: maybe synergy has something to do with this.

The first article summarizing the Pollack-Zheng effect gives quantitative support for this picture. I have formatted the text as comments to the summary represented in the article of Mae-Wan Ho [D64].

Exclusion zones

The article summarizes the sequence of events initiated by the discovery of Gerald Pollack and his student Jian-ming Zheng [D72, D66]. As a matter fact, the fascinating findings described in detail by Gerald Pollack in his book were absolutely crucial for the recent TGD based view about quantum biology in which dark matter plays key role.

1. Pollack and his student discovered that suspensions of colloids and dissolved substances are excluded from a region extending some hundreds of micrometres from the surfaces of hydrophilic gels. An "exclusion zone" (EZ) of this magnitude conflicts the belief that interfacial water forming at liquid-solid, or liquid-air interfaces can be no more than a few layers of molecules thick. What's observed is a million layers or more! "Exclusion" means that the water suspension of micro-spheres moved away from the surface of gel with constant velocity and behaving like single structural unit.

   Comment: The sizes of cells vary up to hundreds of micrometers and cells are by definition structures which are isolated from the environment. Maybe EZs represent protocells or their precedessors. Pollack and coauthors have indeed proposed that their finding might relate to the origin of life [D66]. That the surface was that of gel might be important. In TGD based model of living matter gels have magnetic bodies and their presence might relate to the formation of the thick water layer in non-standard phase.

2. Similar exclusion zones were found next to any hydrophilic surface including surfaces coated with a monolayer of hydrophilic molecules, and around ion exchange resin beads. Electric charge appears to be important, as EZ failed to form around charge-exhausted resin beads.

Although EZ can form in pure water, it is enhanced and stabilized by low concentrations of buffer (2 to 10 mM at pH 7).

Comment: Hydrophily could correspond to the formation of magnetic flux tubes connecting the hydrophilic surface to water molecules as assumed in the model of protein folding and bio-catalysis [K10].

3. The EZ phase is very different from the bulk water. An unusually ordered crystalline phase where the molecules are less free to move is suggestive. The UV and visible absorption spectrum gave a single absorption peak at $\lambda \simeq 270$ nm in the UV region completely absent in the bulk phase. The infrared emission record showed that the EZ radiates very little compared with bulk water, as would be expected on account of the reduced mobility of water molecules. The magnetic resonance imaging mapping similarly gave a transverse relaxation time (T2) of 25.4 + 1 ms, which is shorter than the 27.1 + 0.4 ms recorded for the bulk water phase, again indicative of restricted motion.

Comment: The reduced radiation might mean that part of photons are dark and bound inside magnetic flux tubes defining a structure responsible for the formation of gel like phases inside cell and perhaps also inside EZ. The interpretation as bio-photons is suggestive. This phase of water could be precedessor of the water in cell interior since in the crystalline phase long bio polymers like DNA and amino-acid sequences would be stable against hydration.

4. EZ had a different electrical potential from the bulk phase, by as much as 100 200 mV, depending on the hydrophilic surface. With a negatively charged surface such as polyacrylic acid or Nafion (widely used as a proton exchange membrane), the potential is negative compared with the bulk water away from the EZ. Simultaneously, the hydrogen ion (proton, H^+) concentration is high just outside the EZ, decreasing in a gradient away from it. This indicates that the formation of the EZ is accompanied by a separation of positive and negative electrical charges, which led to the build up of electrical potential between the EZ and the bulk water. In effect, the water has become an electrical battery, and can provide electricity through an external circuit.

Comment: Cell membrane is also a battery and the potential is around 50-80 mV to be compared with 100 200 mV, and the size scale of cell varies from 5 micrometer to hundreds of micrometers so that EZs could be involved with the formation of cell and cell membranes. The kicking of electrons or protons to smaller space-time sheet could be the mechanism inducing electric potential at a given space-time sheet. The formation of battery would mean that water could some day used to store very effectively the energy of solar radiation.

A connection with photosynthesis

Separating H^+ from e^- (electron) is the first step of photosynthesis in green plants which provides energy for most of the biosphere. In this case the energy comes from solar radiation. The separation of charges requires energy also in the case of EZ and the question is where this energy comes from in the case of EZ.

1. A clue came after having inadvertently left the experimental chamber with the EZ on the microscope overnight. Next morning, the EZ had shrunk considerably. But after turning on the microscope lamp, it began to immediately grow again, restoring itself within minutes to its former size. The energy for EZ formation comes from light, as in photosynthesis, but it can use the low energy part of the solar spectrum that photosynthesis cannot.

Comment: Could one consider the possibility that photosynthesis involves unknown step and this step is just the kicking of electrons or protons to a smaller space-time sheet. This step would also induce the separation of charges and the generation of electric potential.

2. Although the entire spectrum of visible light appeared effective in making the EZ grow, the most effective part is in the infrared region, peaking at $\lambda \simeq 3100$ nm. A 10 minute exposure at that wavelength expanded the width of an EZ 3.7 times, and after an hour of exposure, the expansion was more than 6 times. After the light was turned off, the EZ remained constant

for about 30 minutes before beginning to shrink, reaching halfway to its baseline level in about 15 minutes.

Comment: $\lambda = 3100$ nm corresponds to.4 eV. The nominal value of the fundamental metabolic energy quantum is around $E_0 = .5$ eV and one has $E(k = 0, n = 3) = 0.4375$ eV for this value of E_0. Perhaps the photons indeed kick electrons or protons to a smaller space-time sheet.

(a) In the case of protons the smaller space-time sheet would correspond to atomic space-time sheets characterized by $p \simeq 2^{137}$: the larger one would correspond to to $k = 141$.

(b) For electrons the size of the smaller space-time sheet would be by a factor $m_p/m_e = 940/.5 = 1880 \simeq 2^{11}$ larger and would correspond to $k = 137 + 11 = 148$. This served as one motivation for the original $\hbar/\hbar_0 = 2^{11k}$ hypothesis for the preferred values of Planck constant. This is one half of the thickness of the lipid layer of cell membrane. The larger space-time sheet would correspond to cell membrane thickness $L(151) = 10$ nm and perhaps the dark space-time sheet serving as a template for the formation of the cell membrane! If $E = .4$ eV corresponds to electron, then proton would correspond to $E(0, 3) = .44$ eV giving for the metabolic energy quantum the value $E_0(p) = 0.5029$ eV in the case of proton and $E_0(e) = 0.4616$ eV in the case of electron.

3. When the UV and visible range was tested, a peak in the degree of EZ expansion was detected at $\lambda = 270$ nm in the UV region, corresponding to the characteristic absorption peak of EZ that was identified before. However, as the optical power used in the UV and visible region was 600 times that in the IR, the most profound effect was identified in the IR region, particularly at 3 100 nm.

Comment: $\lambda = 270$ nm corresponds to the energy 4.5926 eV. E=4 eV is the nearest metabolic energy quantum. This energy does not correspond directly to any metabolic energy quantum assignable to.4 eV or.43 eV. One must be however cautious with conclusions since the model is very rough.

4. The mechanism of EZ formation is still unknown. But the two wavelengths that expand the EZ most effectively may offer some hint. The UV wavelength 270 nm is close to the 250 nm ($\simeq 5$ eV) required to ionize water under standard state conditions and taking into account the hydration of the resulting ions. The 3 100 nm peak, on the other hand is close to the OH stretch of the ring hexamer identified as the most abundant species in infrared predissociation spectroscopy of large water clusters, and also in neon matrices by infrared spectroscopy. These results suggest that photoexcitation of ring hexamers and photoionisation followed by ejection of protons play synergistic roles in the assembly of the EZ phase. Pollack and colleagues believe that the infrared radiation, though normally insufficient to break OH bonds, can nevertheless work via resonance induced dissociation of large hydrogen-bonded networks.

Comment: Ring hexamers bring in mind the crucial role of aromatic cycles in TGD inspired model of DNA as topological quantum computer which leads also to a model of ADP$\leftrightarrow$ ATP transition involving reconnection of magnetic flux tubes and having also information theoretic interpretation as a change of the topology of the braid structure defining topological quantum computer program [K5]. Magnetic flux tubes carrying dark electrons begin from these and can end up to other bio-molecules or water. Just a guess: could they end on ring hexamers?

Summary

The findings suggest additional details to the TGD based view about living matter.

1. The kicking of electrons or protons or both of them to a larger space-time sheet would be the first step in photosynthesis as I indeed suggested for years ago. The energy of 3100 nm photons indeed corresponds to that for the fundamental metabolic energy quantum. I have also proposed this process to be a fundamental step also in bio-catalysis: the temporary dropping of electron or proton of the catalyst molecule could provide the energy helping the reacting molecules to overcome the potential wall preventing the reaction from running. This

metabolic coin could be returned to catalyst with high enough probability or the photons exchanged could be virtual.

In many-sheeted space-time particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries of space-time sheet of a given system. Also p-adic phase transition increasing the size of the space-time sheet could take place and the liberated energy would correspond to the reduction of zero point kinetic energy. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant h_{eff} so that cyclotron energy would be liberated.

2. The findings suggest also a mechanism for how solar radiation generates proto cells or their precedessors. The resulting phases of water have size extending to those for largest cells and the water could involve a gel like phase in which magnetic flux tubes containing dark matter could play a key role and eventually lead to quantum computer like behavior [K5]. The kicking of electrons (or protons) to smaller space-time sheet would induce ionization at given space-time sheet so that electric potential difference would result. The magnitude of the potential difference is of a correct order of magnitude. Cell membrane scale is present as a p-adic length scale for the space-time sheet of electrons before the kicking to the smaller space-time sheet and these space-time sheets could act as templates for the formation of cell membrane.

3. Interestingly, TGD based model of high T_c super conductivity predicts that both cell membrane length scale and size scale of cell are involved with the super-conductivity [K25]. Cell membrane acts as a Josephson junction in TGD based model of cell membrane, nerve pulse, and EEG.

7.7 Pollack's Findings About Fourth Phase Of Water And The Model Of Cell

The discovery of negatively charged exclusion zone formed in water bounded by gel phase has led Pollack to propose the notion of gel like fourth phase of water. In this article this notion is discussed in TGD framework. The proposal is that the fourth phase corresponds to negatively charged regions - exclusion zones - with size up to 100-200 microns generated when energy is fed into the water - say as radiation, in particular solar radiation. The stoichiometry of the exclusion zone is $H_{1.5}O$ and can be understood if every fourth proton is dark proton residing at the flux tubes of the magnetic body assignable to the exclusion zone and outside it.

This leads to a model for prebiotic cell as exclusion zone. Dark protons are proposed to form dark nuclei whose states can be grouped to groups corresponding to DNA, RNA, amino-acids, and tRNA and for which vertebrate genetic code is realized in a natural manner. The voltage associated with the system defines the analog of membrane potential, and serves as a source of metabolic energy as in the case of ordinary metabolism. The energy is liberated in a reverse phase transition in which dark protons transform to ordinary ones. Dark proton strings serve as analogs of basic biopolymers and one can imagine analog of bio-catalysis with enzymes replaced with their dark analogs. The recent discovery that metabolic cycles emerge spontaneously in absence of cell support this view.

One can find a biographical sketch [?] (`http://tinyurl.com/ycqtuchp`) giving a list of publications containing items related to the notions of exclusion zone and fourth phase of water discussed in the talk.

7.7.1 Pollack's Findings

I list below some basic experimental findings about fourth gel like phase of water made in the laboratory led by Gerald Pollack [L23].

1. In water bounded by a gel a layer of thickness up to 100-200 microns is formed. All impurities in this layer are taken outside the layer. This motivates the term "exclusion zone". The layer

consists of layers of molecular thickness and in these layers the stoichiometry is $H_{1.5}O$. The layer is negatively charged. The outside region carries compensating positive charge. This kind of blobs are formed in living matter. Also in the splitting of water producing Brown's gas negatively charged regions are reported to emerge [H9, H1].

2. The process requires energy and irradiation by visible light or thermal radiation generates the layer. Even the radiation on skin can induce the phase transition. For instance, the blood flow in narrow surface veins requires metabolic energy and irradiation forces the blood to flow.

3. The layer can serve as a battery: Pollack talks about a form of free energy deriving basically from solar radiation. The particles in the layer are taken to the outside region, and this makes possible disinfection and separation of salt from sea water. One can even understand how clouds are formed and mysteries related to the surface tension of water as being due the presence of the layer formed by $H_{1.5}O$.

4. In the splitting of water producing Brown's gas [H9, H1] having a natural identification as Pollack's fourth phase of water the needed energy can come from several alternative sources: cavitation, electric field, etc...

7.7.2   Dark Nuclei And Pollack's Findings

While listening the lecture of Pollack I realized that a model for dark water in term of dark proton sequences is enough to explain the properties of the exotic water according to experiments done in the laboratory of Pollack. There is no need to assume sequences of half-dark water molecules containing one dark proton each.

Model for the formation of exclusion zones

The data about formation of exclusion zones allows to construct a more detailed model for what might happen in the formation of exclusion zones.

1. The dark proton sequences with dark proton having size of order atomic nucleus would reside at the flux tubes of dark magnetic field which is dipole like field in the first approximation and defines the magnetic body of the negatively charged water blob. This explains the charge separation if the flux tubes have length considerably longer than the size scale of the blob which is given by size of small cell. In the model inspired by Moray B. King's lectures charge separation is poorly understood.

2. An interesting question is whether the magnetic body is created by the electronic currents or whether it consists of flux tubes carrying monopole flux: in the latter case no currents would be needed. This is obviously purely TGD based possibility and due to the topology of CP_2.

3. This means that in the model inspired by the lectures of Moray B. King discussed above, one just replaces the sequences of partially dark water molecules with sequences of dark protons at the magnetic body of the $H1.5O$ blob. The model for the proto-variants of photosynthesis and metabolism remain as such. Also now genetic code would be realized [K53, L3].

4. The transfer of impurities from the exclusion zone could be interpreted as a transfer of them to the magnetic flux tubes outside the exclusion zone as dark matter.

These primitive forms of photosynthesis and metabolism form could be key parts of their higher level chemical variants. Photosynthesis by irradiation would induce a phase transition generating dark magnetic flux tubes (or transforming ordinary flux tubes to dark ones) and the dark proton sequences at them. Metabolism would mean burning of the resulting blobs of dark water to ordinary water leading to the loss of charge separation. This process would be analogous to the catabolism of organic polymers liberating energy. Also organic polymers in living matter carry their metabolic energy as dark proton sequences: the layer could also prevent their hydration. That these molecules are typically negatively charged would conform with the idea that dark protons at magnetic flux tubes carry the metabolic energy.

The liberation of energy would involve increase of the p-adic prime characterizing the flux tubes and reduction of Planck constant so that the thickness of the flux tubes remains the same but the intensity of the magnetic field is reduced. The cyclotron energy of dark protons is liberated in coherent fashion and in good approximation the frequencies of the radiation corresponds to multiplies of cyclotron frequency: this prediction is consistent with that in the original model for the findings of Blackman and others [J28].

The phase transition generating dark magnetic flux tubes containing dark proton sequences would be the fundamental step transforming inanimate matter to living matter and the fundamental purpose of metabolism would be to make this possible.

Minimal metabolic energy consumption and the value of membrane potential

This picture raises a question relating to the possible problems with physiological temperature.

1. The Josephson radiation generated by cell membrane has photon energies coming as multiples of ZeV, where V is membrane potential about .06 V and $Z = 2$ is the charge of electron Cooper pair. This gives $E = .12$ eV.

2. There is a danger that thermal radiation masks Josephson radiation. The energy for photons at the maximum of the energy density of blackbody radiation as function of frequency is given as the maximum of function $x^3/(e^x - 1)$, $x = E/T$ given by $e^{-x} + x/3 - 1 = 0$. The maximum is given approximately by $x = 3$ and thus $E_{max} \simeq 3T$ (in units $c = 1, k_B = 1$). At physiological temperature $T = 310$ K (37 C) this gives .1 eV, which is slightly below Josephson energy: living matter seems to have minimized the value of Josephson energy - presumably to minimize metabolic costs. Note however that for the thermal energy density as function of *wavelength* the maximum is at $E \simeq 5T$ corresponding to 1.55 eV which is larger than Josephson energy. The situation is clearly critical.

3. One can ask whether also a local reduction of temperature around cell membrane in the fourth phase of water is needed.

    "Electric expansion" of water giving rise to charge separation and presumably creating fourth phase of water is reported to occur [H9, H1].

    (b) Could the electric expansion/phase transition to dark phase be adiabatic involving therefore no heat transfer between the expanding water and environment? If so, it would transform some thermal energy of expanding water to work and reduce its temperature. The formula for the adiabatic expansion of ideal gas with f degrees of freedom for particle ($f = 3$ if there are no other than translational degrees of freedom) is $(T/T_0) = (V/V_0)^{-\gamma}$, $\gamma = (f + 2)/f$. This gives some idea about how large reduction of temperature might be involved. If p-adic scaling for water volume by a power of two takes place, the reduction of temperature can be quite large and it does not look realistic.

    (c) The electric expansion of water need not however involve the increase of Planck constant for water volume. Only the Planck constant for flux tubes must increase and would allow the formation of dark proton sequences and the generation of cyclotron Bose-Einstein condensates or their dark analog in which fermions (electrons in particular) effectively behave as bosons (the anti-symmetrization of wave function would occur in dark degrees of freedom corresponding to multi-sheeted covering formed in the process).

7.7.3   Fourth Phase Of Water And Pre-Biotic Life In TGD Universe

Metabolism and fourth phase of water

If the fourth phase of water defines pre-biotic life form then the phase transition generating fourth phase of water and its reversal are expected to be fundamental elements of the ordinary metabolism, which would have developed from the pre-biotic metabolism. The following arguments conforms with this expectation.

1. Cell interiors, in particular the interior of the inner mitochondrial membrane are negatively charged as the regions formed in Pollack's experiments. Furthermore, the citric acid cycle, (`http://tinyurl.com/y8ubjgnc`), which forms the basic element of both photosynthesis (`http://tinyurl.com/yauwzkho`) and cellular respiration `http://tinyurl.com/ybeefxmb`, involves electron transport chain (`http://tinyurl.com/yat3m4vk`) in which electron loses gradually its energy via production of NADP and proton at given step. Protons are pumped to the other side of the membrane and generates proton gradient serving as metabolic energy storage just like battery. The interpretation for the electron transport chain in terms of Pollack's experiment would be in terms of generation of dark protons at the other side of the membrane.

2. When ATP is generated from ADP three protons per ATP flow back along the channel formed by the ATP synthase molecule (`http://tinyurl.com/yd5ndcyk`) (perhaps Josephson junction) and rotate the shaft of a "motor" acting as a catalyst generating three ATP molecules per turn by phosphorylating ADP. The TGD based interpretation is that dark protons are transformed back to ordinary ones and possible negentropic entanglement is lost.

3. ATP is generated also in glycolysis (`http://tinyurl.com/ybzgdgve`), which is ten-step process occurring in cytosol so that membrane like structure need not be involved. Glycolysis involves also generation of two NADH molecules and protons. An open question (to me) is whether the protons are transferred through an endoplasmic reticulum or from a region of ordered water (fourth phase of water) to its exterior so that it would contribute to potential gradient and could go to magnetic flux tubes as dark proton. This would be natural since glycolysis is realized for nearly all organisms and electron transport chain is preceded by glycolysis and uses as input the output of glycolysis (two pyruvate molecules (`http://tinyurl.com/y8v7aq9s`)).

4. Biopolymers - including DNA and ATP - are typically negatively charged. They could thus be surrounded by fourth phase of water and neutralizing protons would reside at the magnetic bodies. This kind of picture would conform with the idea that the fourth phase (as also magnetic body) is fractal like. In phosphorylation the metabolic energy stored to a potential difference is transferred to shorter length scales (from cell membrane scale to molecular scale).

In glycolysis (`http://tinyurl.com/ybzgdgve`) the net reaction $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2(g) + 6H_2O(l) + heat$ takes place. The Gibbs free energy change is $\Delta G = -2880$ kJ per mole of $C_6H_{12}O_6$ and is negative so that the process takes place spontaneously. Single glucose molecule is theoretized to produce $N = 38$ ATP molecules in optimal situation but there are various energy losses involved and the actual value is estimated to be 29-30. From $Joule = 6.84 \times 10^{18}$ eV and $mol = 6.02 \times 10^{23}$ and for $N = 38$ one would obtain the energy yield .86 eV per single ATP. The nominal value that I have used .5 eV. This is roughly 5 to 8 times higher than $E = ZeV, Z = 2$, which varies in the range .1-.16 eV so that the metabolic energy gain cannot be solely due to the electrostatic energy which would actually give only a small contribution.

In the thermodynamical approach to metabolism the additional contribution would be due to the difference of the chemical potential μ for cell exterior and interior, which is added to the membrane potential as effective potential energy. The discrepancy is however rather large and this forces the question the feasibility of the model. This forces to reconsider the model of osmosis in the light of Pollack's findings.

Pollack's findings in relation to osmosis and model for cell membrane and EEG

Osmosis (`http://tinyurl.com/yc5dbtzv`) has remained to me poorly understood phenomenon. Osmosis means that solvent molecules move through a semipermeable membrane to another side of the membrane if the concentration of solute is higher at that side. Solute can be water or more general liquid, supercritical liquid, and even gas.

Osmosis is not diffusion: it can occur also towards a higher concentration of water. Water molecules are not attracted by solute molecules. A force is required and the Wikipedia explanation is that solute molecules approaching pores from outside experience repulsion and gain momentum which is transferred to the water molecules.

The findings of Pollack inspire the question whether the formation of exclusion zone could relate to osmosis and be understood in terms of the fourth phase of water using genuine quantal description.

In the thermodynamical model for ionic concentrations one adds to the membrane resting potential a contribution from the difference of chemical potentials μ_i at the two sides of the membrane. Chemical potentials for the ions parametrize the properties of the cell membrane reducing basically to the properties of the channels and pumps (free diffusion and membrane potential do not entirely determine the outcome).

If the transfer of ions - now protons - through cell membrane is quantal process and through Josephson junctions defined by transmembrane proteins, then the thermodynamical model can at best be a phenomenological parameterization of the situation. One should find the quantum counterpart of thermodynamical description, and here the identification of quantum TGD as square root of thermodynamics in Zero Energy Ontology (ZEO) suggests itself. In this approach thermodynamical distributions are replaced by probability amplitudes at single particle level such that their moduli squared give Boltzmann weights.

1. Simplest Josephson junction model for cell membrane

The first guess is that quantum description is achieved by a generalization of the Josephson junction model allowing different values of Planck constant at magnetic flux tubes carrying dark matter.

1. Josephson junctions correspond microscopically to transmembrane proteins defining channels and pumps. In rougher description entire cell membrane is described as Josephson junction.

2. The magnetic field strength at flux tube can differ at the opposite side of the membrane and even the values of h_{eff} could in principle be different. The earlier modelling attempts suggest that $h_{eff}/h = n = 2^k A$, where A is the atomic weight of ion, is a starting assumption deserving testing. This would mean that each ion resides at its own flux tubes.

   The phase transitions changing the value of h_{eff} could induce ionic flows through cell membrane, say that occurring during nerve pulse since the energy difference defining the ratio of square roots of Boltzmann weights at the two sides of the membrane would change. Also the change of the local value of the magnetic field could do the same.

   Consider first the simplest model taking into account only membrane potential.

1. The simplest model for Josephson junction defined by the transmembrane protein is as a two state system (Ψ_1, Ψ_2) obeying Schrödinger equation.

$$i\hbar_1 \frac{\partial \Psi_1}{\partial t} = ZeV\Psi_1 + k_1\Psi_2 \ ,$$

$$i\hbar_2 \frac{\partial \Psi_2}{\partial t} = k_2\Psi_2 \ .$$

One can use the decomposition $\Psi_i = R_i exp(i\Phi(t))$ to express the equations in a more concrete form. The basic condition is that the total probability defined as sum of moduli squared equals to one: $R_1^2 + R_2^2 = 1$. This is guaranteed if the hermiticity condition $k_1/\hbar_1 = \overline{k_2}\hbar_2$ holds true. Equations reduce to those for an ordinary Josephson junction except that the frequency for the oscillating Josephson current is scaled down by $1/h_{eff}$.

2. One can solve for R_2 assuming $\Phi_1 = eVt/\hbar_{eff}$. This gives

$$R_2(t) = sin(\Phi_0) + \frac{k_1}{\hbar_1} sin(\frac{eVt}{\hbar_1}) \ .$$

R_2 oscillates around $sin(\Phi_0)$ and the concentration difference is coded by $\Phi 0$ taking the role of chemical potential as a phenomenological parameter.

3. The counterparts of Boltzmann weights would be apart from a phase factor square roots of ordinary Boltzmann weights defined by the exponent of Coulomb energy:

$$R = sin(\phi_0) = exp(\frac{ZeV(t)}{2T}) \quad .$$

Temperature would appear as a parameter in single particle wave function and the interpretation would be that thermodynamical distribution is replaced by its square root in quantum theory. In ZEO density matrix is replaced by its hermitian square root multiplied by density matrix.

2. The counterpart of chemical potential in TGD description

This model is not as such physically realistic since the counterpart of chemical potential is lacking. The most straightforward generalization of the thermodynamical model is obtained by the addition of an ion dependent chemical potential term to the membrane potential: $ZeV \to ZeV + \mu_I$. This would however require a concrete physical interpretation.

1. The most obvious possibility is that also the chemical potential actually correspond to an interaction energy - most naturally the cyclotron energy $E_c = \hbar_{eff} Z e B_{end}/m$ of ion - in this case proton - at the magnetic flux tube. Cyclotron energy is proportional to h_{eff} and can be rather large as assumed in the model for the effects of ELF em fields on brain.

2. This model would predict the dependence of the effective chemical potential on the mass and charge of ion for a fixed value of on h_{eff} and B_{end}. The scales of ionic chemical potential and ion concentrations would also depend on value of h_{eff}.

3. The model would provide a different interpretation for the energy scale of bio-photons, which is in visible range rather than infrared as suggested by the value of membrane potential.

   The earlier proposal [K50] was that cell membrane can be in near vacuum extremal configuration in which classical Z^0 field contributes to the membrane potential and gives a large contribution for ions. The problematic aspect of the model was the necessity to assume Weinberg angle in this phase to have much smaller value than usually. This difficulty could be perhaps avoided by noticing that the membrane potentials can differ for color receptors so that the earlier assignment of specific ions to color receptors could make sense for ordinary value of Weingerg angle. Second problem is that for proton the Z^0 contribution is negligible in good approximation so that this model does not explain the high value of the metabolic energy currency.

4. The simplest model the communications to magnetic body rely on Josephson radiation whose fundamental frequency f_J is at resonance identical with the cyclotron frequency $f_c(MB)$ at particular part of the flux tube of the magnetic body: $(f_c(MB) = f_J$. $f_c(MB)$ corresponds to EEG frequency in the case of brain and biophotons are produced from dark EEG photons as ordinary photons in phase transition reducing $h_{eff} = n \times h$ to h.

   In the modified model the sum $f_c + f_{J,n}$ ($f_{J,n} = E_J/n \times h$) of h_{eff}-independent cyclotron frequency and Josephson frequency proportional to $1/h_{eff}$ equals to cyclotron frequency $f_c(MB)$ at "personal" magnetic body varying slowly along the flux tube: $f_c + f_{J,n} = f_c(MB)$. If also the variation of f_J assignable to the action potential is included, the total variation of membrane potential gives rise to a frequency band with width roughly

$$\frac{\Delta f}{f} \simeq \frac{2f_{J,n}}{f_c + f_{J,n}} = \frac{2f_{J,1}}{nf_c + f_{J,1}} \quad .$$

   If dark photons correspond to biophotons the energy is of cyclotron photon is in visible and UV range one has $nf_c = E_{bio}$ and

$$\frac{\Delta f}{f} \simeq \frac{2ZeV}{E_{bio} + ZeV} \quad .$$

   The prediction is scale invariant and same for all ions and also electron unless E_{bio} depends on ion. For $eV = .05$ eV, $Z = 1$, and $E_{bio} = 2$ eV ($f \simeq 5 \times 10^{14}$ Hz) one has $\Delta f/f \sim .1$ giving 10 per cent width for EEG bands assumed in the simpler model.

If this vision is on the correct track, the fundamental description of osmosis would be in terms of a phase transition to the fourth phase of water involving generation of dark matter transferred to the magnetic flux tubes. For instance, the swelling of cell by an in-flow of water in presence of higher concentration inside cell could be interpreted as a phase transition extending exclusion zone as a process accompanied by a phase transition increasing the value of h_{eff} so that the lengths of the flux tube portions inside the cell increase and the size of the exclusion zone increases. In general case the phase transitions changing h_{eff} and B_{end} by power of two factor are possible. This description should bring magnetic body as part of bio-chemistry and allow understanding of both equilibriumion distributions, generation of nerve pulse, and basic metabolic processes leading to the generation of ATP.

One can also model sensory receptors and try to understand the maximal sensitivity of color receptors to specific wavelengths in this framework. The new degrees of freedom make this task easy if one is only interested in reproducing these frequencies. More difficult challenge is to understand the color receptors from the first principles. It is also possible to combine the new view with the assumption that sensory receptor cells are near to vacuum extremals. This would add a cyclotron contribution to the generalized Josephson frequency depending only weakly on particle and being non-vanishing also for em neutral particles.

Why would charge separation generate large h_{eff}?

The basic question is whether and how the separation of electron and proton charges generates large h_{eff}? A possible mechanism emerged from a model [K109] explaining anomalously large gravimagnetic effect claimed by Tajmar *et al* [E7, E9] to explain the well-established anomaly related to the mass of Cooper pairs in rotating super-conduction. The mass is too large by fraction of order 10^{-4} and the proposal is that gravimagnetism changes slightly the effective Thomson magnetic field associated with the rotating super-conductor leading to wrong value of Cooper pairs mass when only ordinary Thomson field is assumed to be present. The needed gravimagnetic field is however gigantic: 28 orders larger than that predicted by GRT. Gravimagnetic field is proportional h_{eff}^2 in TGD and if one uses h_{gr} for electron-Earth system one obtains correct order of magnitude.

Nottale's finding that planetary orbits seem to correspond to Bohr orbits in gravitational potential with gigantic value of gravitational Planck constant is the basic input leading to the model of gravimagnetic anomaly.

1. By Equivalence Principle h_{gr} has the general form $h_{gr} = GMm/v_0$, where M and m are the interacting masses and v_0 is a parameter with dimensions of velocity. For 4 inner planets one has $v_0/c \simeq 2^{-11}$.

2. The notion of h_{gr} generalizes to that for other interactions. For instance, in electromagnetic case the formation of strong em fields implying charge separation leads to systems in which $h_{em} = Z_1 Z_2 e^2/v_0$ is large. Pollack's exclusion zone and its complement define this kind of systems and is identified as prebiotic life form.

3. Since the natural expansion parameter of perturbative expansion is the $g^2/4\pi\hbar$, one can say that transition to dark matter phase make the situation perturbative. Mother Nature is theoretician friendly.

h_{em} might be large in the exclusion zones (EZ) appearing in the water bounded by gel and their variants could play central role in living matter.

1. EZ carries very large negative charge with positive charge outside the exclusion zone.

2. TGD interpretation is in terms of $H_{1.5}O$ phase of water formed when every 4: th proton is transferred to magnetic body as dark particle with large value of h_{eff}. The proposal is that primitive life form is in question.

3. The pair formed by EZ and its complement could have large value of $h_{eff} = h_{em} = Z^2 e^2/v_0$.

4. The velocity parameter v_0 should correspond to some natural rotation velocity. What comes in mind is that complement refers to Earth and v_0 is the rotation velocity at the surface of Earth. The prediction for h_{eff} would be of order $h_{em}/h = 4\pi\alpha Z^2 \times .645 \times 10^6 \simeq 5.9 \times 10^4 Z^2$.

5. Cell membrane involves also large charge separation due to very strong electric field over the cell membrane. Also now dark phases with large h_{em} or h_{gr} could be formed.

I have proposed that metabolic machinery generates large h_{eff} phase somehow. $h_{eff} = h_{em}$ hypothesis allows to develop this hypothesis in more detail.

1. I have speculated earlier [K58] that the rotating shaft of a molecular motor associated with ATP synthase plays a key role in generating dark matter phase. What comes in mind is that charge separation takes place associating exclusion zone with the shaft and the rotational velocity v_0 of the shaft appears in the formula for h_{em}. Of course, some numerical constant not far from unity could be present. The electric field over the mitochondrial membrane generates charge separation. One can imagine several identifications for the product of charges. The charge Z associated with the complement would be naturally associated with single dark flux tube containing dark nucleon consisting of dark protons. For instance, the charge associated with the exclusion zone could be the charge of the electronic Cooper pair giving $h_{em} = 2e \times Z/v_0$.

2. The value of v_0/c is expected to be of order 10^{-14} from the angular rotation rate of ADP synthase about few hundred revolutions per second. The order of magnitude for h_{em} could be same as for h_{gr} associated with Earth-particle system.

$h_{eff}(ATP synthase) = h_{gr}(2e, Earth)$ would make possible reconnection of electromagnetic flux tubes with gravimagnetic flux tubes [K90].

Which came first: metabolism or cell membrane?

One of the basic questions of biology is whether metabolism preceded basic biopolymers or vice versa. RNA world scenario assumes that RNA and perhaps also genetic code was first.

1. The above view suggests that both approaches are correct to some degree in TGD Universe. Both metabolism and genetic code realized in terms of dark proton sequences would have emerged simultaneously and bio-chemistry self-organized around them. Dark proton sequences defining analogs of amino-acid sequences could have defined analogs of protein catalysts and played a key role in the evolution of the metabolic pathways from the primitive pathways involving only the phase transition between ordinary water and fourth phase of water.

2. There is very interesting article (see http://tinyurl.com/ycdhd4fd) [?]eporting that complex metabolic pathways are generated spontaneously in laboratory environments mimicking hot thermal vents. Glycolysis and pentose phosphate pathway were detected. The proposal is that these pathways are catalyzed by metals rather than protein catalysts.

3. In standard biology these findings would mean that these metabolic pathways emerged before basic biopolymers and that genetic code is not needed to code for the metabolic pathways during this period. In TGD framework dark genetic code [K53, L3] would be there, and could code for the dark pathways. Dark proton strings in one-one correspondence with the amino-acid sequences could be responsible for catalysts appearing in the pathways. Only later these catalysts would have transformed to their chemical counterparts and might be accompanied by their dark templates. One cannot even exclude the possibility that the chemical realization of the DNA-amino-acid correspondence involves its dark analog in an essential manner.

7.7.4 Could Pollack effect make cell membrane a self-loading battery?

The so called Clarendon dry pile is 175 years old battery still working. The current is very weak (nano Ampere) but the working of the battery is claimed to be not well-understood. The TGD inspired model for cold fusion leads to the proposal that Pollack effect is part of electrolysis. This inspires the idea that Pollack effect and possibly also the associated cold fusion could make

Clarendon dry pile a self-loading battery. Cell membrane can be regarded as the analog of self-loading battery, and in TGD framework also as a generalised Josephson junction. Hence one can ask whether also cell membrane could be seen as a self-loading battery utilizing Pollack's mechanism. This would also allow to understand why hyperpolarization stabilizes the membrane potential and why depolarization generates nerve pulse.

Clarendon pile: 175 years old battery still working

Elemer Rosinger had a Facebook link to an article telling about Clarendon dry pile, a very long-lived battery providing energy for an electric clock (see `http://tinyurl.com/zeut69y`, `http://tinyurl.com/jhrww2a`, and `http://tinyurl.com/gvbrhra`). This clock known also as Oxford bell has been ringing for 175 years now and the article suggests that the longevity of the battery is not really understood. The bell is not actually ringing so loud that human ear could hear it but one can see the motion of the small metal sphere between the oppositely charged electrodes of the battery in the video.

The function principle of the clock is simple. The gravitational field of earth is also present. When the sphere touches the negative electrode, it receives a bunch of electrons and gives the bunch away as it touches positive electrode so that a current consisting of these bunches is running between electrons. The average current during the oscillation period of 2 seconds is nanoampere so that nanocoulomb of charge is transferred during each period (Coulomb corresponds to a 6.242×10^{18} elementary charges (electrons)).

The dry pile was discovered by priest and physicist Giuseppe Zamboni at 1812 (see `http://tinyurl.com/jkvtj6f`). The pile consists of 2,000 pairs of pairs of discs of tin foil glued to paper impregnated with Zinc sulphate and coated on the other side with manganese dioxide: 2,000 thin batteries in series. The operation of battery gradually leads to the oxidation of Zinc and the loss of magnase dioxide but the process takes place very slowly. One might actually wonder whether it takes place too slowly so that some other source of energy than the electrostatic energy of the battery would be keep the clock running. Karpen pile is analogous battery discover by Vasily Karpen (see `http://tinyurl.com/jpzcs32`). It has now worked for 50 years.

Cold fusion is associated with electrolysis. Could the functioning of this mystery clock involve cold fusion taken seriously even by American Physical Society thanks to the work of the group of prof. Holmlid. Electrolytes have of course been "understood" for aeons. Ionization leads to charge separation and current flows in the resulting voltage. With a feeling of deep shame I must confess that I cannot understand how the ionization is possible in standard physics. This of course might be just my immense stupidity - every second year physics student would immediately tell that this is "trivial" - so trivial that he would not even bother to explain why. The electric field between the electrodes is immensely weak in the scale of molecules. How can it induce the ionisation? Could ordinary electrolytes involve new physics involving cold fusion liberating energy? These are the questions which pop up in my stupid mind. Stubborn as I am in my delusions, I have proposed what this new physics might be with inspiration coming from strange experimental findings of Gerald Pollack, cold fusion, and my own view about dark matter has phases of ordinary matter with non-standard value $h_{eff} = n \times h$ of Planck constant. Continuing with my weird delusions I dare ask: Could cold fusion provide the energy for the "miracle" battery?

What batteries are?

To understand what might be involved one must first learn some basic concepts. I am trying to do the same.

1. Battery (see `http://tinyurl.com/8xqsnab`) consistes of two distinct electrochemical cells (see `http://tinyurl.com/jq8ljmo`). Cell consists of electrode and electrolyte. The electrodes are called anode and catode. By definition electron current along external wire flows to catode and leaves anode.

2. There are also ionic currents flowing inside the battery. In absence of the ionic currents the electrodes of the battery lose their charge. In the loading the electrodes get their charges. In the ideal situation the ionic current is same as electron current and the battery does not lose its charging. Chemical reactions are however taking place near and at the electrodes and in

their reversals take place during charging. Chemical changes are not completely reversible so that the lifetime of the battery is finite.

The ionic current can be rather complex: the carriers of the positive charge from anode can even change during the charge transfer: what matters that negative charge from catode is transferred to anode in some manner and this charge logistics can involve several steps. Near the catode the currents of positive ions (cations) and electrons from the anode combine to form neutral molecules. The negative current carriers from catode to the anode are called anions.

3. The charge of the clectrochemical cell is in the electrolyte near the surface of the electrode rather than inside it as one might first think and the chemical processes involve neutralization of ion and the transfer of neutral outcome to or from the electrode.

4. Catode - or better, the electrochemical cell containing the catode - can have both signs of charge. For positive charge one has a battery liberating energy as the electron current connecting the negative and positive poles goes through the load, such as LED. For negative charge current flows only if there is external energy feed: this is loading of the battery. External voltage source and thus energy is needed to drive the negative charges and positive charges to the electrodes. The chemical reactions involved can be rather complex and proceed in reverse direction during the loading process. Travel phone battery is a familiar example.

During charging the roles of the anode and catode are changed: understanding this helps considerably.

Could dark cold fusion make possible self-loading batteries?

Could cold fusion help to understand why the Clarendon dry pile is so long lived?

1. The battery is series of very many simpler batteries. The mechanism should reduce to the level of single building brick. This is assumed in the following.

2. The charge of the battery tends to be reduced unless the ionic and electronic currents are identical. Also chemical changes occur. The mechanism involved should oppose the reduction of the charging by creating positive charge to the catode and negative charge to the anode or induce additional voltage between the electrodes of the battery inducing its loading. The energy feed involved might also change the direction of the basic chemical reactions as in the ordinary loading by raising the temperature at catode or anode.

3. Could be formation of Pollack's exclusion zones (EZs) in the elecrolytic cell containing the anode help to achieve this? EZs carry a high electronic charge. According to TGD based model protons are transformed to dark protons at magnetic flux tubes. If the positive dark charge at the flux tubes is transferred to the electrolytic cell containing catode and transformed to ordinary charge, it would increase the positive charge of the catode. The effect would be analogous to the loading of battery. The energy liberated in the process would compensate for the loss of charge energy due to electronic and ionic currents.

4. In the ordinary loading of the battery the voltage between batteries induces the reversal of the chemical processes occurring in the battery. This is due to the external energy feed. Could the energy feed from dark cold fusion induce similar effects now? For instance, could the energy liberated at the catode as positively charged dark nuclei transform to ordinary ones raise the temperature and in this manner feed the energy needed to change the direction of the chemical reactions.

Cell membrane as self-loading battery and how nerve pulse is generated?

This model might have an interesting application to the physics of cell membrane.

1. Cell membrane consisting of two lipid layers defines the analog of a battery. Cell interior plus inner lipid layer (anode) and cell exterior plus outer lipid layer (catode) are analogs of electrolyte cells.

What has been troubling me for two decades is how this battery manages to load itself. Metabolic energy is certainly needed and ADP-ATP mechanism is essential element. I do not however understand how the membrane manages to keep its voltage.

Second mystery is why it is hyperpolarization rather than polarization, which tends to stabilize the membrane potential in the sense that the probability for the spontaneous generation of nerve pulse is reduced. Neither do I understand why depolarization (reduction of the membrane voltage) leads to a generation of nerve pulse involving rapid change of the sign of the membrane voltage and the flow of various ionic currents between the interior and exterior of the cell.

2. In the TGD inspired model for nerve pulse cell interior and cell exterior or at least their regions near to lipid layers are regarded as super-conductors forming a generalized Josephson junction. For the ordinary Josephson junction the Coulombic energy due to the membrane voltage defines Josephson energy. Now Josephson energy is replaced by the ordinary Josephson energy plus the difference of cyclotron energies of the ion at the two sides of the membrane. Also ordinary Josephson radiation can be generated. The Josephson currents are assumed to run along magnetic flux tubes connecting cell interior and exterior. This assumption receives support from the strange finding that the small quantal currents associated with the membrane remain essentially the same when the membrane is replaced with polymer membrane.

3. The model for Clarendon dry pile suggests an explanation for the self-loading ability. The electrolytic cell containing the anode corresponds to the negatively charged cell interior, where Pollack's EZs would be generated spontaneously and the feed of protonic charge to the outside of the membrane would be along flux tubes as dark protons to minimize dissipation. Also ions would flow along them. The dark protons driven to the outside of the membrane transform to ordinary ones or remain dark and flow spontaneously back and provide the energy needed to add phosphate to ADP to get ATP.

4. The system could be quantum critical in the sense that a small reduction of the membrane potential induces nerve pulse. Why the ability to generate Pollack's EZs in the interior would be lost for a few milliseconds during nerve pulse? The hint comes from the fact that Pollack's EZs can be generated by feeding infrared radiation to a water bounded by gel. Also the ordinary Josephson radiation generated by cell membrane Josephson junction has energy in infrared range!

   Could the ordinary Josephson radiation generate EZs by inducing the ionization of almost ionized hydrogen bonded pairs of water molecules. The hydrogen bonded pairs must be very near to the ionization energy so that ordinary Josephson energy of about .06 eV assignable to the membrane voltage is enough to induce the ionization followed by the formation of $H_{3/2}O$. The resulting EZ would consist of layers with the effective stoichiometry $H_{3/2}O$.

   As the membrane voltage is reduced, Josephson energy would not be anymore enough to induce the ionization of hydrogen bonded pair of water molecules, EZs are not generated, and the battery voltage is rapidly reduced: nerve pulse is created. In the case of hyperpolarization the energy excees the energy needed for ionization and the situation becomes more stable.

5. This model could also allow to understand the effect of anesthetes [K88] [L31]. Anesthetes could basically induce hyperpolarization so that Josephson photons would continually generate Pollack's EZ:s and creating of dark particles at the magnetic flux tubes. This need not mean that consciousness is lost at the cell level. Only sensory and motor actions are prevented because nerve pulses are not possible. This prevents formation of sensory and motor mental images at our level of hierarchy.

   Meyer-Overton correlation states that the effectiveness of the anesthete correlates with its solubility to the lipid membrane. This is the case if the presence of anesthete in the membrane induces hyperpolarization so that the energies of the photons of Josephson radiation would be higher than needed for the generation of EZs accompanied by magnetic flux tubes along which ionic Josephson currents would flow between cell interior and exterior. For these quantal currents evidence exists [K92]. In the case of battery these dark ions would flow

from the cell containing anode to that containing catode. For depolarization the energy of Josephson photons would be too low to allow the kicking off protons from hydrogen bonded pairs of water molecules so that EZs would not be created and self-loading would stop and nerve pulse would be generated.

7.8   Implications Of Strong Gravimagnetism For TGD Inspired Quantum Biology

Physicists M. Tajmar and C. J. Matos and their collaborators working in ESA (European Satellite Agency) have made an amazing claim of having detected strong gravimagnetism with gravimagnetic field having a magnitude which is about 20 orders of magnitude higher than predicted by General Relativity [E7]. If the findings are replicable they mean a revolution in the science of gravity and, as one might hope, force a long-waited serious reconsideration of the basic assumptions of the dominating super-string approach.

Tajmar *et al* have proposed [E9] the gravimagnetic effect as an explanation of an anomaly related to the superconductors. The measured value of the mass of the Cooper pair is slightly larger than the sum of masses whereas theory predicts that it should be smaller. The explanation would be that actual London field is larger than it should be because of gravimagnetic contribution to quantization rule used to deduce the value of London field.

TGD explanation of the discrepancy accepting the theory of Tajmar *et al* comes from the proposal inspired by Nottale's observations [E2] suggesting that Bohr's rules apply in planetary system with Planck constant replaced by $\hbar_{gr} = GMm/v_0$. Here M and m are the masses of Sun and planet. $v_0/c \simeq 2^{-11}$ holds true for the 4 inner planets Mercury, Venus, Earth, Mars and $v_0 \rightarrow v_0/5$ and principal quantum number $n_P \geq 2$ for the outer planets. Mars could be also though of as having $v_0/5$ and $n_P = 1$. The rotation velocities of the planets are related to v_0 by Bohr rules. h_{gr} clearly characterizes the pair Sun-planet rather than being fundamental constant whereas the gravitational Compton length GM/v_0 depends on M only. In the TGD framework one assigns gravitational Planck constant to the flux tube connecting the masses and along which the gravitational massless extremals mediating the gravitational interaction are mediated. By Equivalence Principle it is possible to apply the hypothesis only in elementary particle length scales (this does not exclude its application in longer scales) and in these scales $h_{eff} = h_{gr}$ makes sense.

Gravimagnetic London field is proportional to the square of Planck constant and the obvious guess is that the replacement h with h_{gr} could explain the enormous discrepancy with GRT if gravimagnetism is in question. This predicts correctly the magnitude of the effect and one also ends up with the identification of the $h_{gr} = h_{eff}$ in elementary particle scales.

Also a vision about the fundamental role of quantum gravitation in living matter emerges. The earlier hypothesis that dark EEG photons decay to biophotons with energies in visible and ultraviolet range [K30, K20] receives strong quantitative support. This leads also to a simple model for how magnetic bodies control molecular transitions via dark cyclotron radiation with varying frequencies vary but universal energy spectrum since for a given magnetic field all charged particles gives rise to biophotons with same energy. The values of h_{gr}/m and endogenous magnetic field $B_{end} \simeq .2$ Gauss are such that the spectrum of biophotons is in the range of molecular binding energies. This vision would conform with Penrose intuitions about the fundamental role of gravitation in quantum biology.

7.8.1   The Theory fof Tajmar *et al* for fhe Anomaly ff Cooper Pairs Mass

The starting point of the theory of Tajmar and Matos [E9] is the so called London magnetic moment generated in rotating charged super-conductors adding a constant contribution to the exponentially damped Meissner contribution to the magnetic field. This contribution can be understood as being due to the massivation of photons in super-conductors. The modified Maxwell equations are obtained by just adding scalar potential mass term to Gauss law and vector potential mass term to the equation related the curl of the magnetic field to the em current.

The expression for the London magnetic field is given by

$$B = 2\omega_R n_s \times \lambda_\gamma^2 \; , \tag{7.8.1}$$

where ω_R is the angular velocity of superconductor, n_s is charge density of super-conducting particles and $\lambda_\gamma = \hbar/m_\gamma$ is the wave length of a massive photon at rest. In the case of ordinary superconductor one has $\lambda_\gamma = \sqrt{m^*/q^* n_s}$, where $m^* \simeq 2m_e$ and $q^* = -2e$ are the mass and charge of Cooper pair. Hence one has

$$B = -2\frac{m^*}{2e}\omega_R \; . \tag{7.8.2}$$

Magnetic field extends also outside the super-conductor and by measuring it with a sufficient accuracy outside the super-conductor one can determine the value of the electron mass. Instead of the theoretical value $m^*/2m_e = .999992$ which is smaller than one due to the binding energy of the Cooper pair the value $m^*/2m_e = 1.000084$ was found by Tate [E8]. This inspired the theoretical work generalizing the notion of London field to gravimagnetism and the attempt to explain the anomaly in terms of the effects caused by the gravimagnetic field.

Note that in the case of ordinary matter the equations would lead to an inconsistency at the limit $m_\gamma = 0$ since the value of London magnetic field would become infinite. The resolution of the problem proposed in [E9] is based on the replacement of rotation frequency ω with electron's spin precession frequency $\omega_L = -eB/2m$ so that the consistency equation becomes $B = -B = 0$ for a unique choice $1/\lambda_\gamma^2 = -\frac{q}{m}n$. One could also consider the replacement of ω with electron's cyclotron frequency $\omega_c = 2\omega_L$. To my opinion there is no need to assume that the modified Maxwell's equations hold true in the case of ordinary matter.

Gravimagnetic field

The perturbative approach to the Einstein equations leads to equations, which are essentially identical with Maxwell's equations. The g_{tt} component of the metric plays the role of scalar potential and the components g_{ti} define gravitational vector potential. Also the generalization to the super-conducting situation in which graviphotons develop a mass is straightforward. Just add the scalar potential mass term to the counterpart of Gauss law and vector potential mass term to the equation relating the curl of the gravimagnetic field to the gravitational mass current.

In the case of a rotating superconductor London magnetic field is replaced with its gravimagnetic counterpart

$$B_{gr} = -2\omega_R \rho_m \lambda_{gr}^2 \; . \tag{7.8.3}$$

Obviously this formula would give rise to huge gravimagnetic fields in ordinary matter approaching infinite values at the limit of vanishing gravitational mass. Needless to say, these kind of fields have not been observed.

Equivalence Principle however suggests that the gravimagnetic field must be assigned with the rotating coordinate frame of the super-conductor. Equivalence principle would state that seing the things in a rotating reference frame is equivalent of being in a gravimagnetic field $B_{gr} = -2\omega_R$ in the rest frame. This fixes the graviphoton mass to

$$\frac{1}{\lambda_{gr}^2} = (\frac{m_{gr}}{\hbar})^2 = G\rho_m \; . \tag{7.8.4}$$

For a typical condensed matter density parameterized as $\rho_m = Nm_p/a^3$, $a = 10^{-10}$ m this gives the order of magnitude estimate $m_{gr} \sim N^{1/2}10^{-21}/a$ so that graviton mass would be extremely small.

If this is all what is involved, gravimagnetic field should have no special effects. In [E9] it is however proposed that in superconductors a small breaking of Equivalence Principle occurs. The basic assumptions are following.

1. Super-conducting phase and the entire system obey separately the gravitational analogs of Maxwell field equations.

2. The ad hoc assumption is that for super-conducting phase the sign of the gravimagnetic field is opposite to that for the ordinary matter. If purely kinematic effect were in question so that graviphotons were pure gauge degrees of freedom, the value of m_{gr}^2 should should be proportional to ρ_m and $\rho_m - \rho_m^*$ respectively.

3. Graviphoton mass is same for both ordinary and super-conducting matter and corresponds to the net density ρ_m of matter. This is essential for obtaining the breaking of Equivalence Principle.

With these assumptions the gravimagnetic field giving rise to acceleration field detected in the rest system would be given by

$$B_{gr}^* = \frac{\rho_m^*}{\rho} \times 2\omega \tag{7.8.5}$$

This is claimed to give rise to a genuine acceleration field

$$g^* \quad = \quad -\frac{\rho_m^*}{\rho} a \tag{7.8.6}$$

where a is the radial acceleration due to the rotational motion.

Explanation for the too high value of measured electron mass in terms of gravimagnetic field

A possible explanation of the anomalous value of the measured electron mass [E8] is in terms of gravimagnetic field affecting the flux Bohr quantization condition for electrons by adding to the electromagnetic vector potential term $q^* A_{em}$ gravitational vector potential $m^* A_{gr}$. By requiring that the quantization condition

$$\oint (m^* v + q^* A_{em} + m^* A_{gr}) dl \quad = \quad 0 \tag{7.8.7}$$

is satisfied for the superconducting ring, one obtains

$$B \quad = \quad -\frac{2m}{e}\omega - \frac{m}{e}B_{gr} \quad . \tag{7.8.8}$$

This means that the magnetic field is slightly stronger than predicted and it has been known that this is indeed the case experimentally.

The higher value of the magnetic field could explain the slightly too high value of electron mass as determined from the magnetic field. This gives

$$B_{gr} \quad = \quad \frac{\Delta m_e}{m_e} \times 2\omega = \quad \frac{\Delta m_e}{m_e} \times em_e \times B \quad . \tag{7.8.9}$$

The measurement implies $\Delta m_e/m_e = 9.2 \times 10^{-5}$. The model discussed in [E9] predicts $\Delta m_e/m_e \sim \rho^*/\rho$. The prediction is about 23 times smaller than the experimental result.

7.8.2 Is The Large Gravimagnetic Field Possible In TGD Framework?

TGD allows top consider several alternative solutions for the claimed effect.
Many-sheeted space-time could be an essential part of the effect (if real!).

1. In TGD framework both induced metric and various gauge fields are expressible in terms of CP_2 coordinates and their gradients. Hence the gravimagnetic field would be very probably accompanied by an ordinary magnetic field and could be even proportional to it.

2. The ordinary London magnetic field could be accompanied by analogous magnetic field at different space-time sheet playing the same role as gravimagnetic field in the proposed model. Cooper pair would experience both fields by forming topological sum contacts to both space-time sheets carrying ordinary London magnetic field $B = m_e/e\omega_R$ and much smaller London magnetic field $\Delta B = \Delta m/e\omega_R$? There would be no need to introduce gravitation but one should explain why the value of the parameter $\epsilon = \Delta m_e/m_e$ is what it is.

3. In many-sheeted space the gravimagnetic field and accompanying magnetic field would be associated with the flux tubes mediating gravitational interaction with dark matter fraction of Earth's mass. It would not be surprising if the size of the parameter ϵ might be determined by this fraction. Pioneer and Flyby effects [K104] allow to make a rough estimate for the size of this fraction and the outcome is about 2×10^{-4} which is not far from $\epsilon.9 \times 10^{-4}$.

An alternative explanation is that the experiments probe single space-time sheet and that also other Z^0 magnetic field contributes below weak scale which is scaled up for $h_{eff} = n \times h$ and can be macroscopic.

1. TGD predicts the possibility of classical electro-weak fields at larger space-time sheets. If these couple to Cooper pairs generate exotic weak charge at super-conducting space-time sheets the Bohr quantization conditions modify the value of the magnetic field. Exotic weak charge would however mean also exotic electronic em charge so that this option is excluded. It would also require that the Z^0 charge of test bodies used to measure the acceleration field is proportional to their gravitational mass.

2. According to the simplest recent view about Kähler-Dirac action [K123] the modes of Dirac operator are confined to 2-D string world sheets at which classical W boson fields vanish. This guarantees that em charge is well-defined for the modes. The stronger condition that also classical Z^0 field vanishes makes also sense and should hold at least in the length scales in which weak bosons do not appear. This guarantees the absence of axial couplings and parity breaking effects. In living matter parity breaking effects are large and one could consider the possibility that weak length scale is scaled up for $h_{eff} > h$ and that classical Z^0 fields are present below the weak scale.

3. One cannot exclude the possibility that the classical weak fields vanish for entire space-time surface. In this case spinor modes can still be seen as continuous superpositions of 2-D ones. In principle one can consider also other options - such as vanishing of induced Kḧler form or classical em field besides that of W fields.

The conservative option is that classical weak fields vanish in the situation considered so that there is room for the strong gravimagnetic field. The following model starts from the model of Tajmar *et al* and generalizes it by replacing Planck constant with its gravitational counterpart.

Modification of the model of Tajmar *et al* by replacing h with h_{gr}

Gravimagnetic London field is proportional to the square of Planck constant and the obvious guess is that the replacement h with h_{gr} could explain the enormous discrepancy with GRT if gravimagnetism is in question. This predicts correctly the magnitude of the effect and one also ends up with the identification of the $h_{gr} = h_{eff}$ in elementary particle scales.

One can of course develop an objection against the gravimagnetic field proportional h_{eff}^2: also ordinary London magnetic field should be scaled in the same manner due to the proportionality to λ_γ^2. The resulting magnetic field would be enormous. One can however argue that the increase

of Planck constant cannot affect the value of the ordinary London magnetic field. The scaling up of length scales by h_{eff} and flux conservation suggest that the value of B scales down like $1/h_{eff}^2$. This factor is compensated by the h_{eff}^2 factor in the expression of London magnetic field coming from the expression of magnetic penetration length in terms of mass of photon. One can of course ask why magnetic and gravimagnetic London field are different.

1. The formula used by Tajmar *et al* [E9] for the gravimagnetic variant of London magnetic field is direct generalization for the London field for ordinary super-conductor. The gravimagnetic field is proportional to the product $B_g = \omega_R r^2$ of the rotation frequency ω_R of super-conductor and square of the ratio $r = (\lambda_g/\lambda_{g,T})$, where $\lambda_g = \hbar/m_g$ is graviton wave length and $\lambda_{g,T}$ is gravimagnetic penetration length obtained as generalization of the magnetic penetration length for super-conductors by replacing charge with mass. The latter is purely classical quantity whereas graviton wave length depends on Planck constant. Graviton mass can be argued to result in gravitational Meissner effect and can be estimated from the value of cosmological constant Λ being essentially its square root. The resulting value of B_g is too small by 28 orders of magnitude.

2. Tajmar *et al* [E9] suggests that graviton mass is larger by a factor of order 10^{14} in conflict with the experimental upper bound of order 10^{55} kg for m_g. TGD proposal is that it is Planck constant which should be replaced with effective Planck constant $h_{eff} = nh$ equal to gravitational Planck constant h_{gr} for electron Cooper pair in Earth's gravitational field. The model for planetary orbits as Bohr orbits together with Equivalence Principle implies $\hbar_{gr} = GMm/v_0$ at flux tubes connecting particle with mass m to Sun with mass M. v_0 has dimensions of velocity and has order of magnitude correlating with a typical rotation velocity of planetary orbit by Bohr quantization rules.

3. In the recent case the rotation velocity v_0 is the rotation velocity of Earth at its surface: $v_0(E)/c = 2.16 \times 10^{-6}$ to be compared with $v_0(S)/c \simeq .5 \times 10^{-3}$ for Sun-Earth system. The scaling of λ_g is given by $h_{gr}(E, pair)/h = (h_{gr,S,pair}/h) \times (M_E/M_S) \times v_0(S)/v_0(E)$. This gives

$$ r \equiv \frac{h_{gr,S,pair}}{h} = \frac{\lambda(h_{gr,S,pair})}{\lambda(h, pair)} = \frac{\frac{GM}{v_0(S)}}{\lambda_c(pair)} = \frac{\frac{r_S}{v_0(S)}}{\lambda_c(e)} \quad . $$

Using $r_S = 3km$ and $\lambda_e = .243 \times 10^{-12}$ m and $v_0(S) \simeq 2^{-11}$, $M_E/M_S = 3.0 \times 10^{-6}$ one obtains $r \simeq 3.6 \times 10^{14}$. This happens to be correct order of magnitude! Maybe the model might have something to do with reality. Even better, also the value of h_{eff} is consistent with its value spectrum appearing in EEG if one requires that the energy of dark EEG photon with frequency of order 10 Hz is that of biophoton with frequency of about 5×10^{14} Hz. If this picture is correct the values of $h_{eff} = h_{gr}$ would comes as proportional to the masses of particles and cyclotron energies proportional to heB/m would not depend on the mass of the particle at all.

4. What is nice that the model unifies the notions of gravitational Planck constant and dark Planck constant. The basic observation is that Equivalence Principle allows to understand the effects of h_{gr} by reducing it to elementary particle level interpreted in terms of flux tubes connecting particle to the bigger system. This allows to avoid gigantic values of h_{gr} and gives connection with TGD inspired quantum biology. The new quantum physics associated with gravitation would also become key part of quantum biology.

Could $h_{gr} = h_{eff}$ hold true?

The obvious question is whether the gravitational Planck constant deduced from the Nottale's considerations and the effective Planck constant $h_{eff} = nh$ deduced from ELF effects on vertebrate brain and explained in terms of non-determinism of Kähler action could be identical. At first this seems to be non-sensical idea since $\hbar_{gr} = GMm/v_0$ has gigantic value.

It is however essential to realize that by Equivalence Principle one describe gravitational interaction by reducing it to elementary particle level. For instance, gravitational Compton lengths

do not depend at all on the masses of particles. Also the radii of the planetary orbits are independent of the mass of particle mass in accordance with Equivalence Principle. For elementary particles the values of h_{gr} are in the same range as in quantum biological applications. Typically 10 Hz ELF radiation should correspond to energy $E = h_{eff}f$ of UV photon if one assumes that dark ELF photons have energies of biophotons and transform to them. The order of magnitude for n would be therefore $n \simeq 10^{14}$.

The experiments of M. Tajmar *et al* [E7, E9] discussed in [K109] provide a support for this picture. The value of gravimagnetic field needed to explain the findings is 28 orders of magnitude higher than theoretical value if one extrapolates the model of Meissner effect to gravimagnetic context. The amazing finding is that if one replaces Planck constant in the formula of gravimagnetic field with h_{gr} associated with Earth-Cooper pair system and assumes that the velocity parameter v_0 appearing in it corresponds to the Earth's rotation velocity around its axis, one obtains correct order of magnitude for the effect requiring $r \simeq 3.6 \times 10^{14}$.

The most important implications are in quantum biology and Penrose's vision about importance of quantum gravitation in biology might be correct.

1. This result allows by Equivalence Principle the identification $h_{gr} = h_{eff}$ at elementary particle level at least so that the two views about hierarchy of Planck constants would be equivalent. If the identification holds true for larger units it requires that space-time sheet identifiable as quantum correlates for physical systems are macroscopically quantum coherent and gravitation causes this. If the values of Planck constant are really additive, the number of parallel space-time sheets corresponding to non-determinism evolution for the flux tube connecting systems with masses M and m is proportional to the masses M and m using Planck mass as unit. Information theoretic interpretation is suggestive since hierarchy of Planck constants is assumed to relate to negentropic entanglement very closely in turn providing physical correlate for the notions of rule and concept.

2. That gravity would be fundamental for macroscopic quantum coherence would not be surprising since by EP all particles experience same acceleration in constant gravitational field, which therefore has tendency to create coherence unlike other basic interactions. This in principle allows to consider hierarchy in which the integers $h_{gr,i}$ are additive but give rise to the same universal dark Compton length.

3. The model for quantum biology relying on the notions of magnetic body and dark matter as hierarchy of phases with $h_{eff} = n \times h$, and biophotons [K30, K20] identified as decay produces of dark photons. The assumption $h_{gr} \propto m$ becomes highly predictable since cyclotron frequencies would be independent of the mass of the ion.

   (a) If dark photons with cyclotron frequencies decay to biophotons, one can conclude that biophoton spectrum reflects the spectrum of endogenous magnetic field strengths. In the model of EEG [K44] it has been indeed assumed that this kind spectrum is there: the inspiration came from music metaphors suggesting that musical scales are realized in terms of values of magnetic field strength. The new quantum physics associated with gravitation would also become key part of quantum biophysics in TGD Universe.

   (b) For the proposed value of h_{gr} 1 Hz cyclotron frequency associated to DNA sequences would correspond to ordinary photon frequency $f = 3.6 \times 10^{14}$ Hz and energy 1.2 eV just at the lower limit of visible frequencies. For 10 Hz alpha band the energy would be 12 eV in UV. This plus the fact that molecular energies are in eV range suggests very simple realization of biochemical control by magnetic body. Each ion has its own cyclotron frequency but same energy for the corresponding biophoton.

   (c) Biophoton with a given energy would activate transitions in specific bio-molecules or atoms: ionization energies for atoms except hydrogen have lower bound about 5 eV (`http://tinyurl.com/233vcad`). The energies of molecular bonds are in the range 2-10 eV (`http://tinyurl.com/bfsy4ft`). If one replaces v_0 with $2v_0$ in the estimate, DNA corresponds to.62 eV photon with energy tof order metabolic energy currency and alpha band corresponds to 6 eV energy in the molecular region and also in the region of ionization energies.

Each ion at its specific magnetic flux tubes with characteristic palette of magnetic field strengths would resonantly excite some set of biomolecules.This conforms with the earlier vision about dark photon frequencies as passwords.

It could be also that biologically important ions take care of their ionization self. This would be achieved if the magnetic field strength associated with their flux tubes is such that dark cyclotron energy equals to ionization energy. EEG bands labelled by magnetic field strengths could reflect ionization energies for these ions.

(d) The hypothesis means that the scale of energy spectrum of biophotons depends on the ratio M/v_0 of the planet and on the strength of the endogenous magnetic field, which is.2 Gauss for Earth (2/5 of the nominal value of the Earth's magnetic field). Therefore the astrophysical characteristics of planets should be tuned for molecular life. Taking v_0 to be rotational velocity one obtains for the ratio $M(planet)/v_0(planet)$ using the ratio for Earth as unit the following numbers for the planets (Mercury, Venus, Earth, Mars, Jupiter, Saturnus, Uranus, Neptune): $M/v_0 = (8.5, 209, 1, .214223, 1613, 6149, 9359)$. If the energy scale of biophotons is required to be the same, the scale of endogenous magnetic field should be divided by this ratio in order to obtain the same situation as in Earth. For instance, in Mars the magnetic field should be roughly 5 times stronger: in reality the magnetic field of Mars is much weaker. Just for fun one can notice that for Sun the ratio is 1.4×10^6 so that magnetic field should be by the inverse of this factor weaker.

4. An interesting question is how large systems can behave as coherent units with $\hbar_{gr} = GMm/v_0$. In living matter one might consider the possibility that entire organism might be this kind of system. Interestingly, for larger masses the gravitational quantum coherence would be easier. For particle with mass m $h_{gr}/h > 1$ requires larger mass to satisfy $M > M_P^2/m_e$. The first guess that life has evolved from long to shorter scales and reached elementary particle last. Planck mass is the critical mass corresponds to the mass of water blog with volume of size scale of 10^{-4} m (big neuron) is the limit.

5. The Universal gravitational Compton wave length of $GM/v_0 \simeq 864$ meters gives an idea about largest possible living matter system if Earth is the second body. Of course, also other large bodies are possible.In the case of solar system this length is 3×10^3 km. The radius of Earth is 6.37×10^3 km - roughly twice the Compton length. The radii of Mercury, Venus, Earth, Mars, Jupiter, Saturnus, Uranus, Neptunus are (.38, .99, .533, 1, 10.6, 8.6, 4.0, 3.9) using Earth radius as unit the value of h_{gr} is by factor 5 larger than for 4 inner planets so that the values are reasonably near to gravitational Compton length or twice it. Does this mean that dark matter associated with Earth and maybe also other planets is in macroscopic quantum state at some level of the hierarchy of space-time sheets? Does this mean that Mother Gaia as conscious entity might make sense. One can of course make same question in the case of Sun. The universal gravitational Compton length in Sun would be 18 per cent of the radius of Sun if v_0 is taken to be the rotational velocity at the surface of Sun. The radius of solar core, where fusion takes place, is 20-25 per cent of solar radius.

6. There are further interesting numerical coincidences. One can for a moment forget the standard hostility of scientist towards horoscopes and ask whether Sun and Moon could have somehow affect our life via astrocopic quantum coherence. The gravitational Compton length for particle-Moon or particle-Sun system multiplied by the natural value of magnetic field is the relevant parameter. For Sun the parameters in question are mass of Sun, and rotational velocity of Earth with respect to Sun, plus magnetic fields of Sun at flux tubes associated with solar magnetic field measured to be about 5 nT at the position of Earth and 100 times stronger than expected from dipole field behavior. This gives that the range of biophoton energies is scaled down with factor of 1/4 in good approximation so that Father Sun might affect terrestrial biology! If one uses for the rotational velocity of particle at surface of Moon as parameter v_0 (particle would be at Moon), biophoton energy scaled scaled up by factor 1.2.

The general proposal discussed above is testable. In particular, a detailed study of molecular energies with those associated with resonances of EEG could be highly rewarding and reveal the

speculated spectroscopy of consciousness.

What about $h_{em} = h_{eff}$?

The notion of h_{gr} generalizes to that for other interactions. For instance, in electromagnetic case the formation of strong em fields implying charge separation leads to systems in which $h_{em} = Z_1 Z_2 e^2 / v_0$ is large. Pollack's exclusion zone [L23] (`http://tinyurl.com/oyhstc2`) and its complement define this kind of system and TGD inspired identification is as prebiotic life form. I have proposed a TGD inspired model for the fourth phase of water [K67] [L23].

I have proposed that metabolic machinery generates large h_{eff} phase somehow. $h_{eff} = h_{em}$ hypothesis allows to develop this hypothesis in more detail.

1. The rotating shaft of a molecular motor associated with ATP synthase is proposed to play a key role.

2. What comes in mind is that the rotational velocity v_0 of the shaft appears in the formula for h_{em}. The electric field over the mitochondrial membrane generates charge separation and the product of charges of shaft and its complement should appear in the expression for h_{em}.

3. The value of v_0/c is expected to be of order 10^{-14} from the angular rotation rate of ADP synthase about few hundred revolutions per second. The lower bound for the magnitude for h_{em} is same as for h_{gr} associated with Earth-particle system.

Rotating magnetic systems are claimed to exhibit anomalous effects such as spontaneous acceleration and over unity energy production. I have discussed these in [K15].

1. The proposal is that rotating magnetic systems give rise to dark matter at magnetic flux tubes and sheets associated with the system and that the metabolic energy is needed to rotate the motor to generate the dark matter, which in turn makes possible negentropic entanglement characterized the density matrix proportional to unit matrix. This kind of matrix results if entanglement coefficients form a unitary S-matrix characterizing also quantum computation as unitary process.

2. The parameter v_0 appearing in the general formula for h_{eff} assigned with either em - or gravitational flux tubes is identifiable as the rotation velocity. One has $v_0/c \simeq 3 \times 10^{-8}$.

3. Since these systems are strongly charged, a natural guess is that large h_{em} system is in question.

7.8.3 Gravitational Mother Gaia And Life

Negentropic entanglement (NE) is one of the key notions of TGD inspired quantum biology. For instance, it would seem that NE would look more natural metabolic resource than energy. Nutrients should carry it. NE is however not single particle property but between nutrient and some other system in the recent case. What can one say about this system? Can it be part of nutrient? Could it correspond to oxygen molecules? Or could it be Mother Gaia identified in some sensible manner?

If one believes on the presence of gravimagnetic flux tubes and their role as generator of macroscopic quantum coherence in biology then one is forced to consider seriously also NE between its ends. If this is the case then the view of religions about life might be nearer to truth than that of hard-born materialists.

To make this more concrete, let us first look what the transfer of NE could mean.

1. Suppose that nutrient N has NE with unknown system A which a priori could be part of nutrient. Assume that the transfer of NE of nutrient with A is formed by reconnection of U-shaped flux tubes associated with N (or glucose G produced from it) and A so that two parallel flux tubes connecting N and A are formed.

2. The basic operation allowing transformation of $N - A$ NE to $P - A$ NE is following. The two flux tube portions of U-shaped flux associated with the receiver R are reconnected with the two parallel flux tubes connecting N and A so that two flux tubes connecting R to A are formed. NMP strongly suggests that the entanglement remains negentropic in the process.

3. NE is first transferred to P using this process so that P and A are now NE-connected. After this P attaches to ADP to yield ATP and ATP attaches to B and the transfer process leads to NE between B and A.

For ATP synthase the h_{em} consisting two elementary charges is of the same order as h_{gr}. This is probably not an accident. Could this mean that this kind of flux tube can reconnect with gravitational flux tube? Could this make possible a reconnection transforming N-Earth NE to P-Earth NE? This looks plausible.

Consider now the identification of A.

1. If one assumes that the negentropic entanglement (see **Fig.** `http://tgdtheory.fi/appfigures/cat.jpg` or **Fig. ??** in the appendix of this book) corresponds to gravitational flux tubes for N-Earth system then A should be gravitational Mother Gaia, whatever its precise definition might be. N (and glucose) molecules would be alive in the sense that they have NE with Mother Gaia.

2. Could oxygen have some deeper role? For instance, could O_2 molecules serve as analogs of cell membrane receptors for Mother Gaia meaning that gravitational flux tubes go through O_2 molecules? This does not look plausible since metabolism is possible also as fermentation involving no oxygen.

3. In this picture the role of breathing and fermentation would be to make possible the transfer of NE from nutrients to the living system.

This picture allows to imagine about what might happen in biological death. Biological death takes first place only at the highest level of self hierarchy assignable to the our biological body. Cells continue for some time their life even after the last breath. The notion of h_{gr} together with Equivalence Principle suggests that the living biological body has negentropic flux tube connections to both electromagnetic magnetic body (personal magnetic body) and to gravitational Mother Gaia (MG) representing collective consciousness in the scale of Earth. Also personal magnetic body has flux tube connections to MG. The latter especially during sleep. Also connections to higher levels in hierarchy are possible. At the moment of biological death the negentropic flux tube pairs connecting the personal magnetic body to biological body are split and only those with MG remain or are generated in this process. This would happen later at lower levels of biological self hierarchy such as organ and organelles and eventually for cells and biopolymers. On the other hand, new life forms using the decay products as nutrients would take the available NE to use during the decay process.

The quantum model for metabolism allows to understand life as a process in which negentropic entanglement of gravitational Mother Gaia with nutrients is transformed to that of molecules of biological body with personal magnetic body and further processed and enriched. At the moment of biological death this information returns to the gravitational Mother Gaia. By NMP information is not lost but increases steadily giving rise to "Akashic records". This view conforms with the core ideas of spiritual and religious teachings.

7.9 Quantitative Model Of High T_c Super-Conductivity And Bio-Super-Conductivity

I have developed already earlier [K25, K26, K89, K90] a rough model for high T_c super conductivity [D51, D53, D54, D14, D8, D57]. The members of Cooper pairs are assigned with parallel flux tubes carrying fluxes which have either same or opposite directions. The essential element of the model is hierarchy of Planck constants defining a hierarchy of dark matters.

1. In the case of ordinary high T_c super-conductivity bound states of charge carriers at parallel short flux tubes become stable as spin-spin interaction energy becomes higher than thermal energy.

The transition to super-conductivity is known to occur in two steps: as if two competing mechanisms were at work. A possible interpretation is that at higher critical temperature

Cooper pairs become stable but that the flux tubes are stable only below rather short scale: perhaps because the spin-flux interaction energy for current carriers is below thermal energy. At the lower critical temperature the stability would is achieved and supra-currents can flow in long length scales.

2. The phase transition to super-conductivity is analogous to a percolation process in which flux tube pairs fuse by a reconnection to form longer super-conducting pairs at the lower critical temperature. This requires that flux tubes carry anti-parallel fluxes: this is in accordance with the anti-ferro-magnetic character of high T_c super conductivity. The stability of flux tubes very probably correlates with the stability of Cooper pairs: coherence length could dictate the typical length of the flux tube.

3. A non-standard value of h_{eff} for the current carrying magnetic flux tubes is necessary since otherwise the interaction energy of spin with the magnetic field associated with the flux tube is much below the thermal energy.

There are two energies involved.

1. The spin-spin-interaction energy should give rise to the formation of Cooper pairs with members at parallel flux tubes at higher critical temperature. Both spin triplet and spin singlet pairs are possible and also their mixture is possible.

2. The interaction energy of spins with magnetic fluxes, which can be parallel or antiparallel contributes also to the gap energy of Cooper pair and gives rise to mixing of spin singlet and spin triplet. In TGD based model of quantum biology antiparallel fluxes are of special importance since U-shaped flux tubes serve as kind of tentacles allow magnetic bodies form pairs of antiparallel flux tubes connecting them and carrying supra-currents. The possibility of parallel fluxes suggests that also ferro-magnetic systems could allow super-conductivity.

One can wonder whether the interaction of spins with magnetic field of flux tube could give rise to a dark magnetization and generate analogs of spin currents known to be coherent in long length scales and used for this reason in spintronics (`http://tinyurl.com/5cu3qh`). One can also ask whether the spin current carrying flux tubes could become stable at the lower critical temperature and make super-conductivity possible via the formation of Cooper pairs. This option does not seem to be realistic.

In the following the earlier flux tube model for high T_c super-conductivity and bio-super-conductivity is formulated in more precise manner. The model leads to highly non-trivial and testable predictions.

1. Also in the case of ordinary high T_c super-conductivity large value of $h_{eff} = n \times h$ is required.

2. In the case of high T_c super-conductivity two kinds of Cooper pairs, which belong to spin triplet representation in good approximation, are predicted. The average spin of the states vanishes for antiparallel flux tubes. Also super-conductivity associated with parallel flux tubes is predicted and could mean that ferromagnetic systems could become super-conducting.

3. One ends up to the prediction that there should be a third critical temperature T^{**} not lower than $T_{min}^{**} = 2T^*/3$, where T^* is the higher critical temperature at which Cooper pairs identifiable as mixtures of $S_z = \pm 1$ pairs emerge. At the lower temperature $S_z = 0$ states, which are mixtures of spin triplet and spin singlet state emerge. At temperature T_c the flux tubes carrying the two kinds of pairs become thermally stable by a percolation type process involving re-connection of U-shaped flux tubes to longer flux tube pairs and supra-currents can run in long length scales.

4. The model applies also in TGD inspired model of living matter. Now however the ratio of critical temperatures for the phase transition in which long flux tubes stabilize is roughly by a factor 1/50 lower than that in which stable Cooper pairs emerge and corresponds to thermal energy at physiological temperatures which corresponds also the cell membrane potential. The higher energy corresponds to the scale of bio-photon energies (visible and UV range).

7.9.1 A More Detailed Flux Tube Model For Super-Conductivity

The following little calculations support the above vision and lead to quite predictive model.

7.9.2 Simple Quantitative Model

It is best to proceed by building a quantitative model for the situation.

1. Spin-spin interaction energy for electron pair with members de-localized at parallel magnetic flux tubes must be deduced from the standard expression for the magnetic field created by the second charge and from the expression for the magnetic interaction energy of magnetic moment with external magnetic field.

   The magnetic field created by dipole μ outside the dipole is given by

$$B = \frac{\mu_0}{4\pi a^3} \times (3nn \cdot \mu - \mu) \ . \tag{7.9.1}$$

   The factor $\frac{\mu_0}{4\pi}$ can be taken equal to $1/4\pi$ as unity in the units in which $\mu_0 = \epsilon_0 = c = 1$ holds true. n is direction vector associated with the relative position vector a.

   The magnetic interaction energy reads as $E = -\mu \cdot B$ and in the case of identical magnetic moments reads as

$$E = \frac{1}{4\pi a^3} \times (-3\mu_1 \cdot n\mu_2 \cdot n + \mu_1 \cdot \mu_2) \ . \tag{7.9.2}$$

2. The magnetic dipole moment of electron is $\mu = -(ge/2m)S$, $S = \hbar/2$, $g \simeq 2$. For proton analogous expression holds with Lande factor $g = 5.585694713(46)$.

   A simple model is obtained by assuming that the distance between the members of Cooper pair is minimal so that the relative position vector is orthogonal to the flux tubes.

1. This gives for the spin-spin interaction Hamiltonian the expression

$$H_{s-s} = \frac{1}{4\pi a^3} \times (\frac{ge\hbar}{2m})^2 \times O \ , \quad O = -3(m_1)_x(m_2)_x + m_1 \cdot m_2 \ . \tag{7.9.3}$$

   m_i refers to spin in units of $\hbar$. x referes to the direction in the plane defined by flux tubes and orthogonal to them. m_x can be expressed in terms of spin raising and lowering operators as $m_x = (1/2)(m_+ + m_-)$, $m_\pm = m_x \pm im_y$. This gives

$$(m_1)_x(m_2)_x = \tfrac{1}{4} \sum_{i=\pm, j=\pm} (m_i)_1(m_j)_2 \ . \tag{7.9.4}$$

   $m_1 \cdot m_2$ can be expressed as $(1/2) \times [(m_1 + m_2)^2 - m_1^2 - m_2^2]$. In the case of spin 1/2 particles one can have spin singlet and spin triplet and the value of $m_1 \cdot m_2$ is in these cases given by $m_1 \cdot m_2(singlet) = -3/4$ and $m_1 \cdot m_2(triplet) = 1/4$

   The outcome is an expression for the spin-spin interaction Hamiltonian

$$H_{s-s} = E_{s-s} \times O \ , \quad E_{s-s} = \tfrac{1}{4\pi a^3} \times (ge\hbar/2m)^2 \times O \ ,$$

$$O = O_1 + O_2(S) \ , \quad O_1 = -\tfrac{3}{4} \sum_{i=\pm, j=\pm} (m_i)_1(m_j)_2 \ ,$$

$$O_2(singlet) = -\tfrac{3}{4} \ , \quad O_2(triplet) = \tfrac{1}{4} \ .$$

$$\tag{7.9.5}$$

2. The total interaction Hamiltonian of magnetic moment with the magnetic field of flux tube can be deduced as

$$
\begin{aligned}
H_{s-flux} &= -(\mu_Z)_1 B_1 - (\mu_Z)_2 B_2 = \tfrac{ge}{\hbar 2m}(m_1)_z B_1 + (m_2)_z B_2 \\
&= E_{s-flux} \times ((m_1)_z + \epsilon(m_2)_z) \ , \quad E_{s-flux} = \tfrac{ge\hbar B}{2m} \ .
\end{aligned}
\tag{7.9.6}
$$

3. For the diagonalization of spin-spin interaction Hamiltonian the eigenbasis of S_z is a natural choice. In this basis the only non-diagonal terms are O_1 and E_{s-flux}. O_1 does not mix representations with different total spin and is diagonal for the singlet representation. Also the $S_z(tot) = 0$ state of triplet representation is diagonal with respect to O_1: this is clear from the explicit representation matrices of spin raising and lowering operators (the non-vanishing elements in spin $1/2$ representation are equal to 1). $S_z(tot) = 0$ states are eigenstates of O_1 with eigenvalue $+3/4$ for singlet and $-3/4$ for triplet. For singlet one therefore has eigenvalue $o = 0$ and for triplet eigenvalue $o = -1/2$. Singlet does not allow bound state whereas triplet does.

   $S_z(tot) = 1$ and $S_z(tot) = -1$ states are mixed with each other. In this case the O_1 has non-diagonal matrix elements equal to $O_1(1, -1) = O_1(-1, 1) = 1$ so that the matrix representing O is given by

$$
O = \begin{pmatrix} \tfrac{1}{4} & 1 \\ 1 & \tfrac{1}{4} \end{pmatrix} \ .
\tag{7.9.7}
$$

   The eigenvalues are $o_+ = 5/4$ and $o_- = -3/4$. Cooper pairs states are linear combinations of $S_z = \pm 1$ states with coefficients with have either same or opposite sign so that a maximal mixing occurs and the average spin of the pair vanishes.

   To sum up, there are two bound states for mere spin-spin interaction corresponding to $o = -1/2$ spin 0 triplet state and $o = -3/4$ state for which spin 1 and spin -1 states are mixed.

4. For spin singlet at parallel flux tubes the spin-flux interaction vanishes: $H(para, singlet) = 0$. Same holds true for $S_z = \pm 1$ states at biologically especially interesting antiparallel flux tubes: $H(anti, S_z = \pm 1) = 0$. For antiparallel flux tubes $S_z = 0$ states in singlet and triplet are mixed by $H(anti, S_z = 0)$. The two resulting states must have negative binding energy so that one obtains 3 bound states altogether and only one state remains unbound. The amount of mixing and thermal stability of possibly slightly perturbed singlet state is determined by the ratio x of the scale parameters of H_{s-flux} and H_{s-s}.

   The explicit form of $H(anti, S_z = 0)$ is

$$
\begin{aligned}
H(anti, S_z = 0) &= -\frac{E_{s-s}}{2} \begin{pmatrix} 1 & x \\ x & 0 \end{pmatrix} \\
x &= -\frac{4E_{s-flux}}{E_{s-s}} = -32\pi \frac{ma^3}{ge\hbar B} \ , \\
E_{s-s} &= \frac{1}{8\pi}(\frac{ge\hbar}{2m})^2 \frac{1}{a^3} \ .
\end{aligned}
\tag{7.9.8}
$$

   The eigenvalues $H(anti, S_z = 0)$

$$
E_\pm = -\frac{E_{s-s}}{4}(1 \pm \sqrt{1 + 4x^2}) \ .
\tag{7.9.9}
$$

   What is remarkable is that both parallel antiparallel flux tubes give rise to 2 bound states assignable to spin triplet. Singlet does not allow bound states.

5. The Planck constant appearing in the formulas can be replaced with $\hbar_{eff} = n\hbar$. Note that the value of the parameter x is inversely proportional to h_{eff} so that singlet approximation improves for large values of h_{eff}.

7.9.3 Fermionic Statistics And Bosons

What about fermionic statistics and bosons?

1. The total wave function must be antisymmetric and the manner to achieve this for spin triplet state is anti-symmetrization in longitudinal degrees of freedom. In 3-D model for Cooper pairs spatial antis-ymmetrization implies $L = 1$ spatial wave function in the relative coordinate and one obtains $J = 0$ and $J = 2$ states. Now the state could be antisymmetric under the exchange of longitudinal momenta of fermions. Longitudinal momenta cannot be identical and Fermi sphere is replaced by its 1-dimensional variant. In 3-D model for Cooper pairs spatial anti-symmetrization implies $L = 1$ spatial wave function in the relative coordinate. Antisymmetry with respect to longitudinal momenta would be the analog for the odd parity of this wave function. Ordinary super-conductivity is located at the boundary of Fermi sphere in a narrow layer with thickness defined by the binding energy. The situation is same now and the thickness should correspond now to the spin-flux interaction energy.

2. Second possibility is more exotic and could be based on antisymmetric entanglement in discrete dark degrees of freedom defined by the sheets of the singular covering assignable to the integer $n = h_{eff}/h$. For $n = 2m$ one can decompose the n discrete degrees of freedom to the discrete analogs of m spatial coordinates q_i and m canonical momenta p_i and assume that the entanglement matrix proportional to a unitary matrix (negentropic entanglement) is proportional to the standard antisymmetric matrix defining symplectic structure and expressible as a direct sum of 2×2 permutation symbols ϵ_{ij}. $J_{p_i,q_i} = -J_{q_i p_i} = 1/\sqrt{2m}$. This matrix is antisymmetric and unitary in standard sense and quaternionic sense.

3. What about bosons? I have proposed that bosonic ions (such as Ca^{++}) associated with single flux tube form cyclotron Bose Einstein condensates giving rise to spontaneous dark magnetization. Bosonic supra currents can indeed run independently along single flux tube as spin currents. Also now the thermal stability of cyclotron states require large h_{eff}. The supra-currents (spin currents) of bosonic ions could be associated with flux tubes and fermionic supra-currents with their pairs. Even dark photons could give rise to spin currents.

   At the formal level the model applies in the case of bosons too. Symmetrization/anti-symmetrization for spin singlets/triplets would be replaced with anti-symmetrization/symmetrization. The analog of Fermi sphere would be obtained for spin singlet states requiring anti-symmetrization in longitudinal degrees of freedom.

7.9.4 Interpretation In The Case Of High T_c Super-Conductivity

It is interesting to try to interpret the results in terms of high T_c super-conductivity (`http://tinyurl.com/yd8vj9g`).

1. The four eigen values of total Hamiltonian are

$$E = E_{s-s} \times \lambda \ ,$$

$$\lambda \in \{\frac{5}{4}, -\frac{3}{4}, -\frac{1}{4}(1 \pm \sqrt{1 + 4x^2})\} \ . \tag{7.9.10}$$

Two bound states with different binding energies are obtained which should be an empirically testable prediction in the case of the ordinary high T_c superconductivity since it predicts two critical temperatures. Cooper pairs are apart from possible small mixing with singlet state triplet states. The average spin is however vanishing also for $S_z = \pm 1$ states-

2. Two phase transitions giving rise to Cooper pairs are predicted. The simplest interpretation would be that super-conductivity in short scales is already present below the higher critical temperature and corresponds to the currents carries forming a mixture of $S_z = \pm 1$ states. These supra currents would stabilize flux tubes below some rather short scale. At the lower critical temperature the super-conductivity assignable to $S_z = 0$ spin triplets slightly mixed with singlet would become possible and the scale in which supra-currents can run would increase due to the occurrence of the percolation phenomenon. Below the lower critical temperature the interaction with flux tubes is indeed involved in an essential manner as a mixing of singlet and triplet states. One could perhaps say that $S_z = 0$ states stabilize the flux tube pair.

3. The critical temperatures for the stability of Cooper pairs are predicted to be in ratio $3/1 + \sqrt{1 + 4x^2}$ roughly equal the upper bound $3/2$ for small x. The critical temperatures are identical for $x = \sqrt{63/4} \simeq 4$. In the ordinary high T_c super-conductivity in cuprates the two critical temperatures are around $T^* = 300$K and $T_c = 80K$. The ratio $T^*/T_c = 3.75$ fails to be consistent with the upper bound $3/2$.

4. If one takes the model deadly seriously despite its strong simplifying assumptions one is forced to consider a more complex interpretation. What comes in mind is that both kind of Cooper pairs appear first and super-conductivity becomes possible at T_c. T^* would correspond to the emergence of $S_z = \pm 1$ mixtures. The critical temperature T^{**} for the emergence $S_z = 0$ pairs would not be lower than $T^{**}_{min} = (2/3) \times 300 = 200$ K. At temperature T_c the flux tubes carrying the two kinds of pairs become thermally stable by a percolation type process involving re-connection of U-shaped flux tubes to longer flux tube pairs and supra-currents can run in long length scales. This model conforms with the interpretation of pseudo-gap in terms o pre-formed Cooper pairs not able to form coherent supra-currents (http://tinyurl.com/yc543vbl).

One ends up to the prediction that there should be a third critical temperature T^{**} not lower than $T^{**}_{min} = 2T^*/3$, where T^* is the higher critical temperature at which Cooper pairs identifiable as mixtures of $S_z = \pm 1$ pairs emerge. At the lower temperature $S_z = 0$ states, which are mixtures of spin triplet and spin singlet state emerge.

7.9.5 Quantitative Estimates In The Case Of TGD Inspired Quantum Biology

Using the formulas obtained above one can make rough quantitative estimates and get grasp about bio-super-conductivity as predicted by the model.

1. To get grasp to the situation it is good to consider as starting point electron with nanometer scale $a = a_0 = 1$ nm taken as the distance between flux tubes. For $h_{eff} = n \times h$ value of Planck constant one obtains $E_{s-s} = n^2(a/a_0)^3 \times E_0$. $E_0 = 1.7 \times 10^{-7}$ eV.

   Taking $B = 1$ Tesla one obtains for E_{s-flux} $E_{s-flux} = n \times E_{s-flux,0}$, $E_{s-flux,0} = 6.2 \times 10^{-7}$ eV. For $B = B_{end} = .2$ Gauss suggested as an important value of dark endogenous magnetic field one obtains $E_{s-flux,0} = 2.5 \times 10^{-11}$ eV.

2. It seems reasonable to require that the two interaction energies are of same order of magnitude. Spin-flux interaction energy is rather small. For instance, for B=1 Tesla its magnitude for electron is about $E_{s-flux,0} = 6.2 \times 10^{-7}$ eV so that a large value of h_{eff} seems to be necessary.

3. The hypothesis that bio-photons result in the transformations of dark photons to ordinary photons suggests that the energy scale is in the range of visible and UV photons and therefore above eV. This suggests for electron $h_{eff}/h = n \geq 10^7$. The condition that the value of E_{s-s} is also in the same range requires that a scales like $n^{1/3}$. This would give scaling, which is larger than $10^{7/3} \simeq 215$: this would mean $a \geq 2 \times 10^{-7}$ m which belongs to the range of biologically most important length scales between cell membrane thickness and nucleus size.

4. The hypothesis $\hbar_{eff} = n \times \hbar = \hbar_{gr} = GMm/v_0$ [K83, K37, K38, K39, K40] implies that cyclotron energy spectrum is universal (no dependence on the mass of the charged particle. Same would hold true for the spin-flux interaction energy. Spin spin interaction energy is proportional to h_{eff}^2/m^2a^3, where a is minimum distance between members of the Cooper pair. It is invariant under the simultaneous scaling of h_{eff} and m so that all charged particles can form Cooper pairs and spin currents for flux tubes with same distance and same magnetic field strength. This would correspond to the universality of the bio-photons [K20]. This would be also consistent with the earlier explanation for the finding of Hu and Wu [J85] that proton spin-spin interaction frequency for the distance defined by cell membrane thickness is in ELF frequency scale. The proposal was that dark proton sequences are involved at both sides of the membrane.

   Universality of Cooper pair binding energies implies universality of super-conductivity all fermionic ions can form superconducting Cooper pairs as has been assumed in the models for strange effects of ELF em fields on vertebrate brain, for cell membrane as Josephson junction, and for EEG [K44], and in the model for nerve pulse [K92]. As found, Bose-Einstein condensates of bosonic ions could give rise to spontaneous dark magnetization and spin currents along single flux tube so that bosons would be associated with flux tubes and fermions with pairs of them.

   The value of h_{eff} for proton would satisfy $n \geq 2 \times 10^{10}$. This would guarantee that proton cyclotron frequency for $B = B_{end}$ corresponds to thermal energy 2.5×10^{-2} eV at room temperature.

   Note that I have considered also the option that the values of h_{eff} are such that the universal cyclotron energy scale in magnetic field of $B \simeq .2$ Gauss is in the range of bio-photon energies so that h_{eff} would be by a factor of order 50 higher than in the estimate coming from spin temperature.

5. This observation raises the question whether there are two widely different energy scales present in living matter. The first scale would be associated with spin-spin interaction and would correspond to the energy scale of bio-photons. Second scale would be associated with spin-flux interaction and correspond to the energy scale of resting potential just above the thermal energy at physiological temperatures.

   If this is the case, the parameter x would be of order $x \simeq 10^{-2}$ and spin-spin interaction energy would dominate. The somewhat paradoxical earlier prediction was that Cooper pairs in bio-super-conductivity would be stable at temperatures corresponding to energy of eV or even higher but organisms do not survive above physiological temperatures. The critical temperature for living matter could be however understood in terms of the temperature sensitivity of the dark magnetization at magnetic flux tubes. Although the binding energies of Cooper pairs are in bio-photon energy range this does not help since the quantum wires along, which they can propagate are unstable above room temperatures.

6. From the estimate of order 10^{-7} eV for energy scales for $a = 1$ nm and $B = 1$ Tesla and from the binding energy of Cooper pairs of order 10^{-2} eV it is clear that ordinary high T_c super-conductivity cannot correspond to the standard value of Planck constant: $h_{eff}/h \simeq 10^5$ is required. The interpretation would be that at the higher critical temperature Cooper pairs become stable but flux tubes are not stable. At the lower critical temperature also flux tubes become stable. This would correspond to the percolation model that I have proposed earlier.

   These two energy scales would be the biological counterparts of the two much lower energy scales in the ordinary high T_c super-conductivity. There ratio of these scales would be roughly 50.

7.9.6 Does Also Low Tc Superconductivity Rely On Magnetic Flux Tubes In TGD Universe?

Discussions with Hans Geesink have inspired sharpening of the TGD view about bio-superconductivity (bio-SC), high Tc superconductivity (SC) and relate the picture to standard descriptions in a more detailed manner. In fact, also standard low temperature super-conductivity modelled using BCS

theory could be based on the same universal mechanism involving pairs of magnetic flux tubes possibly forming flattened square like closed flux tubes and members of Cooper pairs residing at them.

A brief summary about strengths and weakness of BCS theory

First I try to summarize basics of BCS theory.

1. BCS theory is successful in 3-D superconductors and explains a lot: supracurrent, diamagnetism, and thermodynamics of the superconducting state, and it has correlated many experimental data in terms of a few basic parameters.

2. BCS theory has also failures.

   (a) The dependence on crystal structure and chemistry is not well-understood: it is not possible to predict, which materials are super-conducting and which are not.

   (b) High-Tc SC is not understood. Antiferromagnetism is known to be important. The quite recent experiment demonstrates conductivity- maybe even conductivity - in topological insulator in presence of magnetic field [L28]. This is compete paradox and suggests in TGD framework that the flux tubes of external magnetic field serve as the wires [L28].

3. BCS model based on crystalline long range order and k-space (Fermi sphere). BCS-difficult materials have short range structural order: amorphous alloys, SC metal particles 0-down to 50 Angstroms (lipid layer of cell membrane) transition metals, alloys, compounds. Real space description rather than k-space description based on crystalline order seems to be more natural. Could it be that the description of electrons of Cooper pair is not correct? If so, k-space and Fermi sphere would be only appropriate description of ordinary electrons needed to model the transition to to super-conductivity? Super-conducting electrons could require different description.

4. Local chemical bonding/real molecular description has been proposed. This is of course very natural in standard physics framework since the standard view about magnetic fields does not provide any ideas about Cooper pairing and magnetic fields are only a nuisance rather than something making SC possible. In TGD framework the situation is different.

TGD based view about SC

TGD proposal for high Tc SC and bio-SC relies on many-sheeted space-time and TGD based view about dark matter as $h_{eff} = n \times h$ phase of ordinary matter emerging at quantum criticality [K90].

Pairs of dark magnetic flux tubes would be the wires carrying dark Cooper pairs with members of the pair at the tubes of the pair. If the members of flux tube pair carry opposite B:s, Cooper pairs have spin 0. The magnetic interaction energy with the flux tube is what determines the critical temperature. High Tc superconductivity, in particular the presence of two critical temperatures can be understood. The role of anti-ferromagnetism can be understood.

TGD model is clearly x-space model: dark flux tubes are the x-space concept. Momentum space and the notion of Fermi sphere are certainly useful in understanding the transformation ordinary lattice electrons to dark electrons at flux tubes but the super conducting electron pairs at flux tubes would have different description.

Now come the heretic questions.

1. Do the crystal structure and chemistry define the only fundamental parameters in SC? Could the notion of magnetic body - which of course can correlate with crystal structure and chemistry - equally important or even more important notion?

2. Could also ordinary BCS SC be based on magnetic flux tubes? Is the value of $h_{eff} = n \times h$ only considerably smaller so that low temperatures are required since energy scale is cyclotron energy scale given by E= $h_{eff} = n \times f_c$, $f_c = eB/m_e$. High Tc SC would only have larger h_{eff} and bio-superconductivity even larger h_{eff}!

3. Could it be that also in low Tc SC there are dark flux tube pairs carrying dark magnetic fields in opposite directions and Cooper pairs flow along these pairs? The pairs could actually form closed loops: kind of flattened O:s or flattened squares.

One must be able to understand Meissner effect. Why dark SC would prevent the penetration of the ordinary magnetic field inside superconductor?

1. Could B_{ext} actually penetrate SC at its own space-time sheet. Could opposite field B_{ind} at its own space-time sheet effectively interfere it to zero? In TGD this would mean generation of space-time sheet with $B_{ind} = -B_{ext}$ so that test particle experiences vanishing B. This is obviously new. Fields do not superpose: only the effects caused by them superpose.

   Could dark or ordinary flux tube pairs carrying B_{ind} be created such that the first flux tube portion B_{ind} in the interior cancels the effect of B_{ext} on charge carriers. The return flux of the closed flux tube of B_{ind} would run outside SC and amplify the detected field B_{ext} outside SC. Just as observed.

2. What happens, when B_{ext} penetrates to SC? $h_{eff} \to h$ must take place for dark flux tubes whose cross-sectional area and perhaps also length scale down by h_{eff} and field strength increases by h_{eff}. If also the flux tubes of B_{ind} are dark they would reduce in size in the transition $h_{eff} \to h$ by $1/h_{eff}$ factor and would remain inside SC! B_{ext} would not be screened anymore inside superconductor and amplified outside it! The critical value of B_{ext} would mean criticality for this $h_{eff} \to h$ phase transition.

3. Why and how the phase transition destroying SC takes place? Is it energetically impossible to build too strong B_{ind}? So that effective field $B_{eff} = B_{dark} + B_{ind} + B_{ext}$ experienced by electrons is reduced so that also the binding energy of Cooper pair is reduced and it becomes thermally unstable. This in turn would mean that Cooper pairs generating the dark B_{dark} disappear and also B_{dark} disappears. SC disappears.

Wee after writing the above text came the newest news concerning high Tc superconductivity. Hydrogen sulfide - the compound responsible for the smell of rotten eggs - conducts electricity with zero resistance at a record high temperature of 203 Kelvin (–70 degrees C), reports a paper published in Nature. This super-conductor however suffers from a serious existential crisis: it behaves very much like old fashioned super-conductor for which superconductivity is believed to be caused by lattice vibrations and is therefore not allowed to exist in the world of standard physics! To be or not to be!

TGD Universe allows however all flowers to bloom: the interpretation is that the mechanism is large enough value of $h_{eff} = n \times h$ implying that critical temperature scales up. Perhaps it is not a total accident that hydrogen sulfide H2S - chemically analogous to water - results from the bacterial breakdown of organic matter, which according to TGD is high temperature superconductor at room temperature and mostly water, which is absolutely essential for the properties of living matter in TGD Universe.

As a matter fact, H_2S is used by some bacteria living in deep ocean volcanic vents as a nutrient and also in our own gut: chemically this means that H_2S acts as electron donor in primitive photosynthesis like process to give ATP. That sulphur is essential for growth and physical functioning of plants might be due to the fact that it preceded oxygen based life [F1]. For instance, Cys and met containing sulphur are very important amino-acids.

Indications for high T_c superconductivity at 373 K with $h_{eff}/h = 2$

Some time ago I learned about a claim of Ivan Kostadinov [D49] about superconductivity at temperature of 373 K (100 C) (see `http://tinyurl.com/y9hk83ak`). There is also claims by E. Joe Eck about superconductivity: the latest at 400 K [D13] (see `http://tinyurl.com/yc483hsf`). I am not enough experimentalist to be able to decide whether to take the claims seriously or not.

The article of Kostadinov provides a detailed support for the claim. Evidence for diamagnetism (induced magnetization tends to reduce the external magnetic field inside superconductor) is represented: at 242 transition reducing the magnitude of negative susceptibility but keeping it negative takes place. Evidence for gap energy of 15 mV was found at 300 K temperature: this

energy is same as thermal energy $T/2 = 1.5$ eV at room temperature. Tape tests passing 125 A through superconducting tape supported very low resistance (for Copper tape started burning after about 5 seconds).

I-V curves at 300 K are shown to exhibit Shapiro steps (see `http://tinyurl.com/y7qkmubj`) with radiation frequency in the range [5 GHz, 21 THz]. Already Josephson discovered what - perhaps not so surprisingly - is known as Josephson effect (see `http://tinyurl.com/mo8549n`). As one drives super-conductor with an alternating current, the voltage remain constant at certain values. The difference of voltage values between subsequent jumps are given by Shapiro step $\Delta V = hf/Ze$. The interpretation is that voltage suffers a kind of phase locking at these frequencies and alternating current becomes Josephson current with Josephson frequency $f_J = ZeV/h$, which is integer multiple of the frequency of the current. This actually gives a very nice test for $h_{eff} = n \times h$ hypothesis: Shapiro step ΔV should be scaled up by $h_{eff}/h = n$. The obvious question is whether this occurs in the recent case or whether $n = 1$ explains the findings.

The data represented by Figs. 12, 13,14 of [D49] (see `http://tinyurl.com/y9hk83ak`) suggest $n = 2$ for $Z = 2$. The alternative explanation would be that the step is for some reason $\Delta V = 2hf/Ze$ corresponding to second harmonic or that the charge of the charge carrier is $Z = 1$. I have not been able to find any error in my calculation.

1. Fig 12 shows I-V curve at room temperature T=300 K. Shapiro step is now 45 mV. This would correspond to frequency $f = Ze\Delta V/h = 11.6$ THz. The figure text tells that the frequency is $f_R = 21.762$ THz giving $f_R/f \simeq 1.87$. This would suggest $h_{eff}/h = n \simeq f_R/f \simeq 2$.

2. Fig. 13 shows another at 300 K. Now Shapiro step is 4.0 mV and corresponds to a frequency 1.24 THz. This would give $f_R/f \simeq 1.95$ giving $h_{eff}/h = 2$.

3. Fig. 14 shows I-V curve with single Shapiro step equal to about .12 mV. The frequency should be 2.97 GHz whereas the reported frequency is 5.803 GHz. This gives $f_R/f \simeq 1.95$ giving $n = 2$.

Irrespectively of the fate of the claims of Kostadinov and Eck, Josephson effect could allow an elegant manner to demonstrate whether the hierarchy of Planck constants is realized in Nature.

Room temperature superconductivity for alkanes

Super conductivity with critical temperature of 231 C for n-alkanes containing n=16 or more carbon atoms in presence of graphite has been reported (see `http://tinyurl.com/hnefqv9`).

Alkanes (see `http://tinyurl.com/6pm7mz6`) can be linear (C_nH_{2n+2}) with carbon backbone forming a snake like structure, branched (C_nH_{2n+2}, $n \geq 2$) in which carbon backbone splits in one, or more directions or cyclic (C_nH_{2n}) with carbon backbone forming a loop. Methane CH_4 is the simplest alkane.

What makes the finding so remarkable is that alkanes serve as basic building bricks of organic molecules. For instance, cyclic alkanes modified by replacing some carbon and hydrogen atoms by other atoms or groups form aromatic 5-cycles and 6-cycles as basic building bricks of DNA. I have proposed that aromatic cycles are superconducting and define fundamental and kind of basic units of molecular consciousness and in case of DNA combine to a larger linear structure.

Organic high T_c superconductivity is one of the basic predictions of quantum TGD. The mechanism of super-conductivity would be based on Cooper pairs of dark electrons with non-standard value of Planck constant $h_{eff} = n \times h$ implying quantum coherence is length scales scaled up by n (also bosonic ions and Cooper pairs of fermionic ions can be considered).

The members of dark Cooper pair would reside at parallel magnetic flux tubes carrying magnetic fields with same or opposite direction: for opposite directions one would have $S = 0$ and for the same direction $S = 1$. The cyclotron energy of electrons proportional to h_{eff} would be scaled up and this would scale up the binding energy of the Cooper pair and make super-conductivity possible at temperatures even higher than room temperature [K90].

This mechanism would explain the basic qualitative features of high T_c superconductivity in terms of quantum criticality. Between gap temperature and T_c one one would have superconductivity in short scales and below T_c superconductivity in long length scales. These temperatures would correspond to quantum criticality at which large h_{eff} phases would emerge.

What could be the role of graphite? The 2-D hexagonal structure of graphite is expected to be important as it is also in the ordinary super-conductivity: perhaps graphite provides long flux tubes and n-alkanes provide the Cooper pairs at them. Either graphite, n-alkane as organic compound, or both together could induce quantum criticality. In living matter quantum criticality would be induced by different mechanism. For instance, in microtubules it would be induced by AC current at critical frequencies [L31].

How the transition to superconductive state could be induced by classical radiation?

Blog and Facebook discussions have turned out to be very useful and quite often new details to the existing picture emerge from them. We had interesting exchanges with Christoffer Heck in the comment section to "Are microtubules macroscopic quantum systems?" (see `http://tinyurl.com/hwnnfcd`) and this pleasant surprise occurred also now.

Recall that Bandyopadhyay's team claims to have detected the analog of superconductivity, when microtubules are subjected to AC voltage [J19, J75] (see `http://tinyurl.com/ze366ny`). The transition to a state resembling superconductivity would occur at certain critical frequencies. For the TGD inspired model see [L22].

The TGD proposal for bio-superconductivity - in particular that appearing in microtubules - is same as that for high T_c superconductivity [K89, K90]. Quantum criticality, large $h_{eff}/h = n$ phases of Cooper pairs of electrons, and parallel magnetic flux tube pairs carrying the members of Cooper pairs for the essential parts of the mechanism. $S = 0$ ($S = 1$) Cooper pairs appear when the magnetic fields at parallel flux tubes have opposite (same) direction.

Cooper pairs would be present already below the gap temperature but possible super-currents could flow in short loops formed by magnetic flux tubes in ferromagnetic system. AC voltage at critical frequency would somehow induce transition to superconductivity in long length scales by inducing a phase transition of microtubules without helical symmetry to those with helical symmetry and fusing the conduction pathways with length of 13 tubulins associated with micro-tubules of type B to much longer ones associated with microtubules of type A by the reconnection of magnetic flux tubes parallel to the conduction pathways.

The phonon mechanism responsible for the formation of Cooper pair in ordinary superconductivity cannot be involved with high T_c superconductivity nor bio-superconductivity. There is upper bound of about 30 K for the critical temperature of BCS superconductors. Few days ago I learned about high T_c superconductivity around 500 K for n-alkanes (see `http://tinyurl.com/hwac9e9`) so that the mechanism for high T_c is certainly different [K90].

The question of Christoffer was following. Could microwave radiation for which photon energies are around 10^{-5} eV for the ordinary value of Planck constant and correspond to the gap energy of BCS superconductivity induce phase transition to BCS super-conductivity and maybe to micro-tubular superconductivity (if it exists at all)?

This inspires the question about how precisely the AC voltage at critical frequencies could induce the transition to high T_c - and bio-super-conductivity. Consider first what could happen in the transition to high T_c super-conductivity.

1. In high T_c super conductors such as copper-oxides the anti-ferromagnetism is known to be essential as also 2-D sub-lattice structures. Anti-ferromagnetism suggests that closed flux tubes form of squares with opposite directions of magnetic field at the opposite sides of square. The opposite sides of the square would carry the members of Cooper pair.

2. At quantum criticality these squares would reconnect to very long flattened squares by recon-nection. The members of Cooper pairs would reside at parallel flux tubes forming the sides of the flattened square. Gap energy would consists interaction energies with the magnetic fields and the mutual interaction energy of magnetic moments.

   This mechanism does not work in standard QM since the energies involved are quite too low as compared to thermal energy. Large $h_{eff}/h = n$ would however scale up the magnetic energies by n. Note that the notion of gap energy should be perhaps replaced with collective binding energy per Cooper pair obtained from the difference of total energies for gap phase formed at higher temperature and for superconducting phase formed at T_c by dividing with the number of Cooper pairs.

Another important distinction to BCS is that Cooper pairs would be present already below gap temperature. At quantum criticality the conduction pathways would become much longer by reconnection. This would be represent an example about "topological" condensed matter physics. Now hover space-time topology would be in question.

3. The analogs of phonons could be present as transversal oscillations of magnetic flux tubes: at quantum criticality long wave length "magneto-phonons" would be present. The transverse oscillations of flux tube squares would give rise to reconnection and formation of

If the irradiation or its generalization to high T_c works the energy of photon should be around gap energy or more precisely around energy difference per Cooper pair for the phases with long flux tubes pairs and short square like flux tubes.

1. To induce superconductivity one should induce formation of Cooper pairs in BCS superconductivity. In high T_c super-conductivity it should induce a phase transition in which small square shaped flux tube reconnect to long flux tubes forming the conducting pathways. The system should radiate away the energy difference for these phases: the counterpart of binding energy could be defined as the radiated energy per Cooper pair.

2. One could think the analog of stimulated emission (see `http://tinyurl.com/hwac9e9`). Assume that Cooper pairs have two states: the genuine Cooper pair and the non-superconducting Cooper pair. This is the case in high T_c superconductivity but not in BCS superconductivity, where the emergence of superconductivity creates the Cooper pairs. One can of course ask whether one could speak about the analog of stimulated emission also in this case.

3. Above T_c but below gap temperature one has the analog of inverted population: all pairs are in higher energy state. The irradiation with photon beam with energy corresponding to energy difference gives rise to stimulated emission and the system goes to superconducting state with a lower energy state with a lower energy.

This mechanism could explain the finding of Bandyopadhyay's team [J19, J75] that AC perturbation at certain critical frequencies gives rise to a ballistic state resembling superconductivity (no dependence of the resistance on the length of the wire so that the resistance must be located at its ends). The team used photons with frequency scales of MHz, GHz, and THz. The corresponding photon energy scales are about 10^{-8} eV, 10^{-5}, $10-2$ eV for the ordinary value of Planck constant and are below thermal energies.

In TGD classical radiation should have also large $h_{eff}/h = n$ photonic counterparts with much larger energies $E = h_{eff} \times f$ to explain the quantal effects of ELF radiation at EEG frequency range on brain [K82]. The general proposal is that h_{eff} equals to what I have called gravitational Planck constant $\hbar_{gr} = GMm/v_0$ [K37, K38, K39, K40, K83]. This implies that dark cyclotron photons have universal energy range having no dependence on the mass of the charged particle. Bio-photons have energies in visible and UV range much above thermal energy and would result in the transition transforming dark photons with large $h_{eff} = h_{gr}$ to ordinary photons.

One could argue that AC field does not correspond to radiation. In TGD framework this kind of electric fields can be interpreted as analogs of standing waves generated when charged particle has contacts to parallel "massless extremals" representing classical radiation with same frequency propagating in opposite directions. The net force experienced by the particle corresponds to a standing wave.

Irradiation using classical fields would be a general mechanism for inducing bio-superconductivity. Superconductivity would be generated when it is needed. The findings of Blackman and other pioneers of bio-electromagnetism about quantal effects of ELF em fields on vertebrate brain stimulated the idea about dark matter as phases with non-standard value of Planck constant. The precise mechanism for how this happens has remained open. Also these finding could be interpreted as a generation of superconducting phase by this phase transition.

7.9.7 The implications of TGD view about magnetic fields for superconductivity

TGD predicts two kinds of magnetic fields depending on whether flux tubes carry monopole flux or not. In Maxwellian framework flux tubes cannot carry any monopole flux. In TGD based model

of high Tc superconductivity [K89, K90] monopole flux tubes current carriers are dark having nonstandard value $h_{eff} = n \times h_0$ of effective Planck constant. Also in bio-superconductivity monopole flux tubes are current carriers. An open question has been whether also ordinary super-conductivity could correspond to monopole flux tubes and I have considered the possibility that this is the case.

The recent progress in understanding the relationship between two kinds of magnetic fields allows to consider more precisely the relationship between these two kinds of super-conductivities. In particular, one can try to understand Meissner effect in ordinary super-conductivity and its absence in the predicted super-conductivity based on monopole flux tubes. The conclusion is that ordinary super-conductivity corresponds to ordinary flux tubes and that Meissner effect has no counterpart in monopole superconductivity.

It is best to start from the ordinary super-conductivity by making an unpleasant question. Meissner effect (see http://tinyurl.com/hesedf2) relates to the possible penetration of magnetic field to super-conductor. Supra-current creates a local magnetic field. Why doesn't this magnetic field destroy super-conductivity?

The answer would be in TGD space-time following.

1. The super-conductor consists of parallel cylindrical tubes carrying supra-currents at their boundaries. These currents create magnetic fields rotating around the cylinders but have no component in z- direction. Magnetic fields vanish at the boundaries of the cylinders.

2. Superconductors can be classified to two types. For superconductors of type I (see http://tinyurl.com/y4wkzcql) one has $\lambda/\xi < 1/\sqrt{2}$ whereas for superconductors of type II (see http://tinyurl.com/y279phzb) one has $\lambda/\xi > 1/\sqrt{2}$. Here λ is the magnetic penetration length, which is roughly the radius of magnetic flux tube. ξ is the coherence length which is roughly the radius of cylinder carrying supra current at its boundary.

   Supra-current generates vortices and in this manner serves as a source for magnetic field inside magnetic flux tube of field possibly penetrating into superconductor. Flux tube must contain at least one current carrying flux tube. This cannot the case for superconductor of type I. Therefore, when ordinary magnetic field penetrates to super-conductor of type I above critical value of B, it must do so in the entire super-conductor . For superconductor of type II magnetic field can penetrate superconductor of type II in a cylinder of radius of order λ containing several current carrying cylinders. In this region the super-conductivity is destroyed since supra currents have component rotating along the cylinder giving rise to a longitudinal magnetic field inside the cylinder.

   What about Meissner effect in monopole superconductors?

1. Monopole flux does not require current as its source. Therefore Meissner effect does not prevent super-conductivity by requiring the super-current to be rotational to generate the magnetic field.

2. Also now the presence of supra current inside monopole flux tube serves as a source for an additional rotational contribution to the magnetic field and the rotor of this additional contribution equals to the supra current. Monopole flux tube is deformed as a consequence. This does not however make supra-current rotational.

   Monopole superconductor can be said to be intermediate between types I and II since both coherence length and magnetic length correspond to flux tube radius. A possible interpretation is that monopole superconductivity is at quantum criticality between superconductivities of type I and II.

3. The most plausible option is that the penetration of ordinary magnetic field to monopole super-conductor occur along non-monopole flux tubes at different space-time sheets so that it would therefore not spoil the super-conductivity at the monopole flux tubes.

The group of Suchitra Sebastian has discovered very unconventional condensed matter system, which seems to be simultaneously both insulator and conductor of electricity but only in

presence of magnetic field. Science article is entitled "Unconventional Fermi surface in an insulating state" [L28] (see `http://tinyurl.com/y79qo7lp`). There is also a popular article with title "Paradoxical Crystal Baffles Physicists" in Quanta Magazine summarizing the findings (see `http://tinyurl.com/qhwdmxj`). I learned about the finding first from the blog posting of Lubos Motl (see `http://tinyurl.com/yacm6bj7`).

Observations

The crystal studied at superlow temperatures was Samarium hexaboride - briefly SmB_6. The high resistance implies that electron cannot move more that one atom's width in any direction. Sebastian et al however observed electrons traversing over a distance of millions of atoms- a distance of orde 10^{-4} m, the size of a large neuron. So high mobility is expected only in conductors. SmB_6 is neither metal or insulator or is both of them! The finding is described by Sebastian as a "big schock" and as a "magnificent paradox" by condensed matter theorists Jan Zaanen. Theoreticians have started to make guesses about what might be involved but accorrding to Zaanen there is no even remotely credible hypothesis has appeared yet.

On basis of its electronic structure SmB_6 should be a conductor of electricity and it indeed is at room temperature: the average number conduction electrons per SmB_6 is one half. At low temperatures situation however changes. At low temperatures electrons behave collectivily. In superconductors resistance drops to zero as a consequence. In SmB_6 just the opposite happens. Each Sm nucleus has the average 5.5 electrons bound to it at tight orbits. Below 223 degrees of Celsius the conduction electrons of SmB_6 are thought to "hybridize" around samarium nuclei so that the system becomes an insulator. Various signatures demonstrate that SmB_6 indeed behaves like an insulator.

During last five years it has been learned that SmB_6 is not only an insulator but also so called topological insulator. The interior of SmB_6 is insulator but the surface acts as a conductor. In their experiments Sebastian *et al* hoped to find additional evidence for the topological insulator property and attempted to measure quantum oscillations in the electrical resistance of their crystal sample. The variation of quantum oscillations as sample is rotated can be used to map out the Fermi surface of the crystal. No quantum oscillations were seen. The next step was to add magnetic field and just see whether something interesting happens and could save the project. Suddenly the expected signal was there! It was possible to detect quantum oscillations deep in the interior of the sample and map the Fermi surface! The electrons in the interior travelled 1 million times faster than the electrical resistance would suggest. Fermi surface was like that in copper, silver or gold. A further surprise was that the growth of the amplitude of quantum oscillations as temperature was decreased, was very different from the predictions of the universal Lifshitz-Kosevich formula for the conventional metals.

Could TGD Help To Understand The Strange Behavior Of SmB_6?

There are several indications that the paradoxical effect might reveal the underlying dynamics of quantum TGD. The mechanism of conduction must represent new physics and magnetic field must play a key role by making conductivity possible by somehow providing the "current wires". How? The TGD based answer is completely obvious: magnetic flux tubes - one of the basic distinctions between electrodynamics of Maxwell and its TGD variant! Also the failure of Lischitz-Kosevich formulas should be understood.

1. Single sheet of many-sheeted space-time resembles topological insulator

One should also understand topological insulator property at deeper level, that is the conduction along the boundaries of topological insulator. One should understand why the current runs along 2-D surfaces. In fact, many exotic condensed matter systems are 2-dimensional in good approximation. In the models of integer and fractional quantum Hall effect electrons form a 2-D system with braid statistics possible only in 2-D system. High temperature super-conductivity is also an effectively 2-D phenomenon. By strong form of holography these aspects are also key aspects of quantum TGD at the fundamental level of single space-time sheet when the approximation replacing many-sheeted space-time with that of GRT and standard model does not mask the simplicity of the fundamental dynamics.

1. Many-sheeted space-time is second fundamental prediction TGD. The dynamics of single sheet of many-sheeted space-time should be very simple by the strong form of holography implyhing effective 2-dimensionality. The standard model description of this dynamics masks this simplicity since the sheets of many-sheeted space-time are replaced with single region of slightly curved Minkowski space with gauge potentials sums of induced gauge potentials for sheets and deviation of metric from Minkowski metric by the sum of corresponding deviations for space-time sheets. Could the dynamics of exotic condensed matter systems give a glimpse about the dynamics of single sheet? Could topological insulator and anyonic systems [K84] provide examples of this kind of systems?

2. Second basic prediction of TGD is strong form of holography: string world sheets and partonic 2-surfaces serve as kind of "space-time genes" and the dynamics of fermions is 2-D at fundamental level. It must be however made clear that at QFT limit the spinor fields of embedding space replace these fundamental spinor fields localized at 2-surface. One might argue that the fundamental spinor fields do not make them directly visible in condensed matter physics. Nothing however prevents from asking whether in some circumstances the fundamental level could make itself visible.

   In particular, for large h_{eff} dark matter systems (, whose existence can be deduced from the quantum criticality of quantum TGD) the partonic 2-surfaces with CP_2 size could be scaled up to nano-scopic and even longer size scales. I have proposed this kind of surfaces as carriers of electrons with non-standard value of h_{eff} in QHE and FQHE [K84].

   The long range quantum fluctuations associated with large, $h_{eff} = n \times h$ phase would be quantum fluctuations rather than thermal ones. In the case of ordinary conductivity thermal energy makes it possible for electrons to jump between atoms and conductivity becomes very small at low temperatures. In the case of large scale quantum coherence just the opposite happens as observed. One therefore expects that Lifshitz-Kosevich formula for the temperature dependence of the amplitude does not hold true.

   The generalization of Lifschitz-Kosevich formula to quantum critical case deduced from quantum holographic correspondence by Hartnoll and Hofman [D46] (`http://tinyurl.com/ybednd85` is expected to hold true qualitatively also for quantum criticality in TGD sense. The first guess is that by underlying super-conformal invariance scaling laws typical for critical systems hold true. In the proposed formula the dependence on temperature is via a power of dimensionless parameter $x = T/mu$;, where μ is chemical potential for electron system. As a matter fact, exponent of power of x appears and reduces to first for Lifshitz-Konsevich formula. Since magnetic field is important, one also expects that the ratio of cyclotron energy scale $E_c \propto \hbar_{eff} eB/m_e$ to Fermi energy appears in the formula. One can even make an order of magnitude guess for the value of $h_{eff}/h \sim 10^6$ from the facts that the scale of conduction and conduction velocity were millions times higher than expected.

   Strings are 1-D systems and strong form of holography implies that fermionic strings connecting partonic 2-surfaces and accompanied by magnetic flux tubes are fundamental. At light-like 3-surfaces fermion lines can give rise to braids. In TGD framework AdS/CFT correspondence generalizes since the conformal symmetries are extended. This is possible only in 4-D space-time and for the embedding space $H = M^4 \times CP_2$ making possible to generalize twistor approach [K114].

3. Topological insulator property means from the perspective of modelling that the action reduces to a non-abelian Chern-Simons term. The quantum dynamics of TGD at space-time level is dictated by Kähler action. Space-time surfaces are preferred extremals of Kähler action and for them Kähler action reduces to Chern-Simons terms associated with the ends of space-time surface opposite boundaries of causal diamond and possibly to the 3-D light-like orbits of partonic 2-surfaces. Now the Chern-Simons term is Abelian but the induced gauge fields are non-Abelian. One might say that single sheeted physics resembles that of topological insulator.

4. The effect appears only in magnetic field. I have been talking a lot about magnetic flux tubes carrying dark matter identified as large h_{eff} phases: topological quantization distinguishes TGD from Maxwell's theory: any system can be said to possess "magnetic body", whose

flux tubes can serve as current wires. I have predicted the possibility of high temperature super-conductivity based on pairs of parallel magnetic flux tubes with the members of Cooper pairs at the neighboring flux tubes forming spin singlet or triplet depending on whether the fluxes are have same or opposite direction.

Also spin and electric currents assignable to the analogs of spontaneously magnetized states at single flux tube are possible. The obvious guess is that the conductivity in question is along the flux tubes of the external magnetic field. Could this kind of conductivity explains the strange behavior of SmB_6. The critical temperature would be that in which the parallel flux tubes are stable. The interaction energy of spin with the magnetic field serves as a possible criterion for the stability if the presence of dark electrons stabilizes the flux tubes.

2. Magnetic flux tubes as dark current carriers in quantum criticality

The following represents an extremely childish attempt of a non-specialist to understand how the conductivity might be understood. The current carrying electrons at flux tubes near the top of Fermi surface are current carriers. $h_{eff} = n \times h$ and magnetic flux tubes as current wires bring in the new elements. Also in the standard situation one considers cylinder symmetric solutions of Schrödinger equation in external magnetic field and introduces maximal radius for the orbits so that formally the two situations seem to be rather near to each other. Physically the large h_{eff} and associated many-sheeted covering of space-time surface providing the current wire makes the situation different since the collisions of electrons could be absent in good approximation so that the velocity of charge carriers could be much higher than expected as experiments indeed demonstrate.

Quantum criticality is the crucial aspect and corresponds to the situation in which the magnetic field attains a value for which a new orbit emerges/disappears at the surface of the flux tube: in this situation dark electron phase with non-standard value of h_{eff} can be generated. This mechanism is expected to apply also in bio-superconductivity and to provide a general control tool for magnetic body.

1. Let us assume that flux tubes cover the whole transversal area of the crystal and there is no overlap. Assume also that the total number of conduction electrons is fixed, and depending on the value of h_{eff} is shared differently between transversal and longitudinal degrees of freedom. Large value of h_{eff} squeezes the electrons from transversal to longitudinal flux tube degrees of freedom and gives rise to conductivity.

2. Consider first Schrödinger equation. In radial direction one has harmonic oscillator and the orbits are Landau orbits. The cross sectional area behaves like $\pi R^2 = n_T h_{eff}/2m\omega_c$ giving $n_T \propto 1/h_{eff}$. Increase of the Planck constant scales up the radii of the orbits so that the number of states in cylinder of given radius is reduced. Angular momentum degeneracy implies that the number of transversal states is $N_T = n_T^2 \propto 1/h_{eff}^2$. In longitudinal direction one has free motion in a box of length L with states labelled by integer n_L. The number of states is given by the maximum value N_L of n_L.

3. If the total number of states is fixed to $N = N_L N_T$ is fixed and thus does not depend on h_{eff}, one has $N_L \propto h_{eff}^2$. Quanta from transversal degrees of freedom are squeezed to longitudinal degrees of freedom, which makes possible conductivity.

4. The conducting electrons are at the surface of the 1-D "Fermi-sphere", and the number of conduction electrons is $N_{cond} \simeq dN/d\epsilon \times \delta\epsilon \simeq dN/d\epsilon T = NT/2\epsilon_F \propto 1/h_{eff}^4$. The dependence on h_{eff} does not favor too large values of h_{eff}. On the other hand, if scattering of electrons at flux tubes could be absent. The assumption $L \propto h_{eff}$ increases the range over which current can flow.

5. To get a non-vanishing net current one must assume that only the electrons at the second end of the 1-D Fermi sphere are current carriers. The situation would resemble that in semiconductor. The direction of electric field would induce symmetry breaking at the level of quantum states. The situation would be like that for a mass in Earth's gravitational field treated quantally and electrons would accelerate freely. Schrödinger equation would give rise to Airy functions as its solution.

3. Quantum critical quantum oscillations

What about quantum oscillations in TGD framework?

1. Quantum oscillation refers to de Haas-van Alphen effect (http://tinyurl.com/yaaljv9j) - an oscillation of the induced magnetic moment as a function of $1/B$ with period $\tau = 2\pi e/\hbar A$, where A is the area of the extremal orbit of the Fermi surface, in the direction of the applied field. The effect is explained to be due to the Landau quantization of the electron energy. I failed to really understand the explanation of this source and in my humble opinion the following arguments provide a clearer view about what happens.

2. If external magnetic field corresponds to flux tubes, Fermi surface decomposes into cylinders parallel to the magnetic field since the motion in transversal degrees of freedom is along circles. In the above thought experiment also a quantization in the longitudinal direction occurs if the flux tube has finite length so that Fermi surface in longitudinal direction has finite length. One expects on basis of Uncertainty Principle that the area S of the cross section of Fermi cylinder in momentum space is given by $S \propto h_{eff}^2/\pi R^2$. This follows also from the equation of motion of electron in magnetic field. As the external magnetic field B is increased, the radii of the orbits decrease inside the flux tube, and in momentum space the radii increase.

3. Why does the induced magnetic moment (magnetization) and other observables oscillate?

   (a) The simplest manner to understand this is to look at the situation at space-time level. Classical orbits are harmonic oscillator orbits in radial degree of freedom. Suppose that the area of flux tube is fixed and B is increased. The orbits have radius $r_n^2 = (n+1/2) \times \hbar/eB$ and shrink. For certain field values the flux $eBA = n\hbar$ corresponds to an integer multiple of the elementary flux quantum . of a new orbit at the boundary of the flux tube emerges if the new orbit is near the boundary of Fermi sphere providing the electrons. This is clearly a critical situation.

   (b) In de Haas- van Alphen effect the orbit $n+1$ for B has same radius as the orbit n for $1/B + \Delta(1/B)$: $r_{n+1}(1/B) = r_n(1/B + \Delta(1/B))$. This gives approximate differential equation with respect to n and one obtains $(1/B)(n) = (n+1/2) \times \Delta(1/B)$. $\Delta(1/B)$ is fixed from the condition the flux quantization. When largest orbit is at the surface of the flux, tube the orbits are same for $B(n)$ and $B(n+1)$, and this gives rise to the de Haas - van Alphen effect.

   (c) It is not necessary to assume finite radius for the flux tube, and the exact value of the radius of the flux tube does not play and important role. The value of flux tube radius can be estimated from the ratio of the Fermi energy of electron to the cyclotron energy. Fermi energy about .1 eV depending only on the density of electrons in the lowest approximation and only very weakly on temperature. For a magnetic field of 1 Tesla cyclotron energy is .1 meV. The number of cylinders defined by orbits is about $n = 10^4$.

4. What happens in TGD Universe in which the areas of flux tubes identifiable as space-time quanta are finite? Could quantum criticality of the transition in which a new orbit emerges at the boundary of flux tube lead to a large h_{eff} dark electron phase at flux tubes giving rise to conduction?

   (a) The above argument makes sense also in TGD Universe for the ordinary value of Planck constant. What about non-standard values of Planck constant? For $h_{eff}/h = n$ the value of flux quantum is n-fold so that the period of the oscillation in de Haas - van Alphen effect becomes n times shorter. The values of the magnetic field for which the orbit is at the surface of the flux tube are however critical since new orbit emerges assuming that the cyclotron energy corresponds is near Fermi energy. This quantum criticality could give rise to a phase transition generating non-standard value of Planck constant.

   What about the period $\Delta(1/B)$ For $h_{eff}/h = n$? Modified flux quantization for extremal orbits implies that the area of flux quantum is scaled up by n. The flux changes

by n units for the same increment of $\Delta(1/B)$ as for ordinary Planck constant so that de Haas -van Alphen effect does not detect the phase transition.

(b) If the size scale of the orbits is scaled up by $\sqrt{n}$ as the semiclassical formula suggests the number of classical orbits is reduced by a factor $1/n$ if the radius of the flux tube is not changed in the transition $h \to h_{eff}$ to dark phase. n-sheetedness of the covering however compensates this reduction.

(c) What about possible values of h_{eff}/h? The total value of flux seems to give the upper bound of $h_{eff}/h = n_{max}$, where n_{max} is the value of magnetic flux for ordinary value of Planck constant. For electron and magnetic field for $B = 10$ Tesla and has $n \leq 10^5$. This value is of the same order as the rough estimate from the length scale for which anomalous conduction occurs.

Clearly, the mechanism leading to anomalously high conductivity might be the transformation of the flux tubes to dark ones so that they carry dark electrons currents. The observed effect would be dark, quantum critical variant of de Haas-van Alphen effect!

Also bio-superconductivity is quantum critical phenomenon and this observation would suggests sharpening of the existing TGD based model of bio-super-conductivity. Super-conductivity would occur for critical magnetic fields for which largest cyclotron orbit is at the surface of the flux tube so that the system is quantum critical. Quantization of magnetic fluxes would quantify the quantum criticality. The variation of magnetic field strength would serve as control tool generating or eliminating supra currents. This conforms with the general vision about the role of dark magnetic fields in living matter.

To sum up, a breakthrough of TGD is continuing. I have written about thirty articles during this year - more than one article per week. There is huge garden there and trees contain fruits hanging low! It is very easy to pick them: just shatter and let them drop to the basket! New experimental anomalies having a nice explanation using TGD based concepts appear on weekly basis and the mathematical and physical understanding of TGD is taking place with great leaps. It is a pity that I must do all alone. I would like to share. I can only hope that colleagues could take the difficult step: admit what has happened and make a fresh start.

7.10 A New Control Mechanism Of TGD Inspired Quantum Biology

The idea that TGD Universe is quantum critical, is the corner stone of quantum TGD and fixes the theory more or less uniquely since the only coupling constant parameter of the theory - Kähler coupling strength - is analogous to critical temperature. Also more than one basic parameters are in principle possible - maximal quantum criticality fixes the values of all of them - but it seems that only Kähler coupling strength is needed. TGD Universe is a quantum critical fractal: like a ball at the top of hill at the top of hill at.... Quantum criticality allows to avoid the fine tuning problems plaguing as a rule various unified theories.

7.10.1 Quantum Criticality

The meaning of quantum criticality at the level of dynamics has become only gradually clearer. The development of several apparently independent ideas generated for about decade ago have led to the realization that quantum criticality is behind all of them. Behind quantum criticality are in turn number theoretic vision and strong forms of general coordinate invariance and holography.

1. The hierarchy of Planck constants defining hierarchy of dark phases of ordinary matter corresponds to a hierarchy of quantum criticalities assignable to a fractal hierarchy of sub-algebras of super-symplectic algebra for which conformal weights are n-ples of those for the entire algebra, n corresponds to the value of effective Planck constant $h_{eff}/h = n$. These algebras are isomorphic to the full algebra and act as gauge conformal algebras so that a broken super-conformal invariance is in question.

2. Quantum criticality in turn reduces to the number theoretic vision about strong form of holography. String world sheets carrying fermions and partonic 2-surfaces are the basic objects as far as pure quantum description is considered. Also space-time picture is needed in order to test the theory since quantum measurements always involve also the classical physics, which in TGD is an exact part of quantum theory.

   Space-time surfaces are continuations of collections of string world sheets and partonic 2-surfaces to preferred extremals of Kähler action for which Noether charges in the sub-algebra of super-symplectic algebra vanish. This condition is the counterpart for the reduction of the 2-D criticality to conformal invariance. This eliminates huge number of degrees of freedom and makes the strong form of holography possible.

3. The hierarchy of algebraic extensions of rationals defines the values of the parameters characterizing the 2-surfaces, and one obtains a number theoretical realization of an evolutionary hierarchy. One can also algebraically continue the space-time surfaces to various number fields - reals and the algebraic extensions of p-adic number fields. Physics becomes adelic. p-Adic sectors serve as correlates for cognition and imagination. One can indeed have string world sheets and partonic 2-surfaces, which can be algebraically continued to preferred extremals in p-adic sectors by utilizing p-adic pseudo constants giving huge flexibility. If this is not possible in the real sector, figment of imagination is in question! It can also happen that only part of real space-time surface can be generated: this might relate to the fact that imaginations can be seen as partially realized motor actions and sensory perceptions.

7.10.2   Quantum Criticality And TGD Inspired Quantum Biology

In TGD inspired quantum biology quantum criticality is in crucial role. First some background.

1. Quantum measurement theory as a theory of consciousness is formulated in zero energy ontology (ZEO) and defines an important aspect of quantum criticality. Strong form of NMP states that the negentropy gain in the state function reduction at either boundary of causal diamond (CD) is maximal. Weak form of NMP allows also quantum jumps for which negentropic entanglement is not generated: this makes possible ethics (good and evil) and morally responsible free will: good means basically increase of negentropy resources.

2. Self corresponds to a sequence state function reductions to the same boundary of CD and h_{eff} does not change during that period. The increase of h_{eff} (and thus evolution!) tends to occur spontaneously, and can be assigned to the state function reduction to the opposite boundary of CD in zero energy ontology (ZEO). The reduction to the opposite boundary means death of self and living matter is fighting in order to avoid this even. To me the only manner to make sense about basic myth of Christianity is that death of self generates negentropy.

3. Metabolism provides negentropy resources for self and hopefully prevents NMP to force the fatal reduction to the opposite boundary of CD. Also homeostasis does the same. In this process self makes possible evolution of sub-selves (mental images dying and re-incarnating) state function by state function reduction so that the negentropic resources of the Universe increase.

7.10.3   A New Mechanism Of Quantum Criticality

Consider now the mechanisms of quantum criticality. The TGD based model [L28] [K37, K38, K39, K40] (http://tinyurl.com/y8oblpl9) for the recent paradoxical looking finding [L28] (http://tinyurl.com/y79qo7lp) that topological insulators can behave like conductors in external magnetic field led to a discovery of a highly interesting mechanism of criticality, which could play a key role in living matter.

1. The key observation is that magnetic field is present. In TGD framework the obvious guess is that its flux tubes carry dark electrons giving rise to anomalous currents running in about million times longer time scales and with velocity, which is about million times higher than expected. Also supra-currents can be considered.

The currents can be formed of the cyclotron energies of electrons are such that they correspond to energies near the surface of the Fermi sphere: recall that Fermi energy for electrons is determined by the density of conduction electrons and is about 1 eV. Interestingly, this energy is at the lower end of bio-photon energy spectrum. In the field of 10 Tesla the cyclotron energy of electron is .1 mV so that the integer characterizing cyclotron orbit must be $n \simeq 10^5$ if conduction electron is to be transferred to the cyclotron orbit.

2. The assumption is that external magnetic field is realized as flux tubes of fixed radius, which correspond to space-time quanta in TGD framework. As the intensity of magnetic field is varied, one observes so called de Haas-van Alphen effect (`http://tinyurl.com/hoywcnq`) used to deduce the shape of the Fermi sphere: magnetization and some other observables vary periodically as function of $1/B$ (for a model for the quantum critical variant of the effect see [D46]).

   This can be understood in the following manner. As B increases, cyclotron orbits contract. For certain increments of $1/B$ $n+1$:th orbit is contracted to n:th orbit so that the sets of the orbits are identical for the values of $1/B$, which appear periodically. This causes the periodic oscillation of say magnetization.

3. For some critical values of the magnetic field strength a new orbit emerges at the boundary of the flux tube. If the energy of this orbit is in the vicinity of Fermi surface, an electron can be transferred to the new orbit. This situation is clearly quantum critical.

   If the quantum criticality hypothesis holds true, $h_{eff}/h = n$ dark electron phase can be generated for the critical values of magnetic fields. This would give rise to the anomalous conductivity perhaps involving spin current due to the spontaneous magnetization of the dark electrons at the flux tube. Even super-conductivity based on the formation of parallel flux tube pairs with either opposite or parallel directions of the magnetic flux such that the members of the pair are at parallel flux tubes, can be considered and I have proposed this a mechanism of bio-superconductivity and also high Tc super-conductivity.

7.10.4 A New Mechanism Of Quantum Bio-Control

The quantum criticality of the process in which new electron orbit emerges near Fermi surface suggests a new mechanism of quantum bio-control by generation of super currents or its reversal.

1. In TGD inspired quantum biology magnetic body uses biological body as motor instrument and sensory receptor and EEG and its fractal variants with dark photons with frequencies in EEG range but energy $E = h_{eff}f$ in the range of bio-photon energies make the necessary signalling possible.

2. Flux tubes can become braided and this makes possible quantum computation like processes [K5]. Also so called 2-braids - defined by knotted 2-surfaces imbedded in 4-D space-time surface - are possible for the string world sheets defined by flux tubes identified to be infinitely thin, are possible. As a matter fact, also genuine string world sheets accompany the flux tubes. 2-braids and knots are purely TGD based phenomenon and not possible in superstring theory or M-theory.

3. It is natural to speak about motor actions of the magnetic body. It is assumed that the flux tubes of the magnetic body connect biomolecules to form a kind of Indra's web explaining the gel like character of living matter. h_{eff} reducing phase transitions contract flux tubes connecting biomolecules so that they can find each other by this process and bio-catalysis becomes possible. This explains the mysterious looking ability of bio-molecules to find each other in the dense molecular soup. In fact the dark matter part is far from being soup! The hierarchy of Planck constants and $h_{eff} = h_{gr}$ hypothesis imply that dark variants of various particles with magnetic moment are neatly at their own flux tubes like books in shelf.

   Reconnection of the U-shaped flux tubes emanating from two subsystems generates a flux tube pair between them and gives rise to supracurrents flowing between them. Also cyclotron radiation propagating along flux tubes and inducing resonant transitions is present. This would be the fundamental mechanism of attention.

4. I have proposed that the variation of the thickness of the flux tubes could serve as a control mechanism since it induces a variation of cyclotron frequencies allowing to get in resonance or out of it. For instance, two molecules could get in flux tube contact when the cyclotron frequencies are identical and this can be achieved if they are able to vary their flux tube thickness. The molecules of immune system are masters in identifying alien molecules and the underlying mechanism could be based on cyclotron frequency spectrum and molecular attention. This would be also the mechanism behind water memory and homeopathy (`http://tinyurl.com/yda3d6se` [K53] which still is regarded as a taboo by mainstreamers.

5. Finally comes the promised new mechanism of bio-control. The variation of the magnetic field induced by that of flux tube thickness allows also to control whether there is quantum criticality for the generation of dark electron supra currents of electrons. The Fermi energy of the conduction electrons at the top of Fermi sphere is the key quantity and dictated by the density of these electrons. This allows to estimate the order of magnitude of the integers N characterizing cyclotron energy for ordinary Planck constant and the maximal value of $h_{eff}/h = n$ cannot be larger than N.

7.11　TGD based model for graphene superconductivity

A highly interesting new effect associated with graphene is discussed in Phys.Org article (see `http://tinyurl.com/ydyqgk56`). The original research articles by Cao *et al* are published in Nature [D20, D21]. There is also a popular article In Nature (see `http://tinyurl.com/ya5jzadc`). What is found that a bilayer formed by parallel graphene sheets becomes superconducting for critical values of twist angle θ. The largest critical value of θ is $\theta = 1.1$ degrees.

　　The finding of Cao *et al* is believed to be highly significant concerning the understanding of high T_c super-conductivity and motivates the development of a model of Mott insulators based on TGD based views about valence bond inspired by the identification of dark matter as $h_{eff}/h = n$ phases of ordinary matter emerging naturally in adelic physics [L51] [L50]. Also a more detailed version about the model of high T_c superconductivity in TGD Universe developed in [K25, K26, K89, K90] emerges.

7.11.1　Basic observations

Consider first the basic facts. The surprising discovery was that graphene becomes unconventional superconductor at temperature 1.7 K. It was already earlier discovered that the coupling of graphene to a superconductor can make also graphene superconducting.

1. The system studied consists of two graphene (see `http://tinyurl.com/8os5eas`) layers twisted by angle θ with respect to each other (rotation of the second sheet by angle θ around the axis normal to sheets). For a generic value of θ the graphene layers behave as separate conductors. For certain critical twist angles below 1.1 degrees the two-layered system however behaves like single unit and Mott insulator (see `http://tinyurl.com/ybqblvc7`): this is due to the increase of the conduction band gap. In an applied electric field the system becomes a super conductor. The electric field provides the energy needed to kick the current carries to the conduction band, which for Mott insulators has higher energy than for the corresponding conductor: at the top of the band Cooper pairs are formed as in the case of ordinary superconductors.

2. A kind of Moire effect (see `http://tinyurl.com/qchunes`) is involved. The twist creates a superlattice with larger unit cell and the electrons associated with periodically occurring C-atom pairs above each other give rise to a narrow band where the superconducting electrons are. Electric field would kick the electrons to this band.

3. There are intriguing analogies with high T_c superconductivity. Electron density as function of temperature has a pattern similar to that for cuprates. Superconductivity occurs at electron density, which is 10^{-4} times that for conventional superconductors at the same temperature. The pairing of electrons cannot be due to phonon exchange since the density is so low. Unidentified strong interaction between electrons is believed to be the reason.

7.11.2 Mott insulators, transition metals, antiferromagnets, and high T_c superconductors in TGD framework

In 1937 Jan Hendrik de Boer and Evert Johannes Willem Verwey pointed out that a variety of transition metal oxides are insulators although they should be conductors since they have odd number of electrons per lattice cells. Nevill Mott and Rudolf Peierls predicted that the effect can be explained by taking into account the interaction between electrons neglected in the band theory of solids. These materials became known as Mott insulators (see `http://tinyurl.com/ybqblvc7`).

1. 1949 Mott proposed a model for NiO as insulator (Ni is transition metal). The conduction was based on the process $(Ni^{2+}O^{2-})^2 \rightarrow Ni^{3+}O^{2-} + Ni^{1+}O^{2-}$. In this process electron is transferred between the neighboring sites. For critical values of parameters NiO however becomes insulator.

   The formation of energy gap preventing conduction can be understood as competition between Coulomb potential U between 3d electrons at the same site and the transfer integral t of 3d electrons between neighboring sites characterizing the transfer of electron between neighboring sites. The total energy bap is $U - 2zt$, where z is the total number of nearest-neighbor atoms. As U is increased by varying parameters a transition to insulator takes place when the energy gap becomes too large.

   t is essentially the matrix element of atomic potential ΔU due to the neighboring atoms taken between two electronic orbitals associated with neighboring atoms. Usually this matrix element is small.

2. It is believed that ordinary quantum mechanics can explain the needed large magnitude of t. The calculations are however not first principle calculations and involve experimental input from chemical bond energy data. Therefore one can ask whether some new physics possible related to the notion of valence bond might be needed.

   In TGD framework one indeed ends up to a model of valence bonds involving non-standard value of $h_{eff}/n = n$ for valence bonds. This could lead to a delocalization of electron wave functions and generate strong interaction between valence electrons of neighboring atoms. This mechanism might apply to all strongly interacting many-electron systems (such as that appearing in QHE and FQHE [K84]) so that the physics of dark matter would make itself visible in condensed matter physics thought to be thoroughly understood at the level of basic principles.

   Remark: The original motivation for the hierarchy of Planck constants was the idea that Nature loves theoreticians [K46, K37, K38, K39, K40]. The phase transition increasing the value of Planck constant reduces the large value of gauge coupling constant $\alpha = g^2/4\pi\hbar$ making perturbation theory impoessible by factor $1/n$ and makes perturbation theory possible.

   The TGD based picture about Mott insulators relies on $h_{eff}/h = n$ hierarchy giving rise to dark matter as phases of ordinary matter. In particular, one ends up with a model for valence bonds with valence electrons having value of n larger than for atoms. This in turn leads to a model of high T_c superconductivity generalizing to a model of Mott insulators. Also graphene superconductivity would rely on these mechanisms.

Dark matter as $h_{eff}/h = n$ phases

It is good to explain first the development of the ideas related to $h_{eff}/h = n$ hierarchy.

1. I ended up to the discovery of dark matter hierarchy and eventually to adelic physics [L50], where $h_{eff}/h = n$ has number theoretic interpretation along several roads starting from anomalous findings.

   One of these roads began from the claim about the existence of strange form of matter by David Hudson [H3]. Hudson associated with these strange materials several names: White Gold, monoatomic elements, and ORMEs (orbitally re-arranged metallic elements). Any colleague without suicidical tendencies would of course refuse to touch anything like White Gold even with a 10 meter long pole but I had nothing to lose anymore. The basic feature is

that these elements would form metal like strongly correlates structure although the atoms are separate so that their is no lattice in the usual sense.

My question was how to explain these elements if they are actually real [K25, K45]. If all valence electrons of this kind of element are dark these element have effectively full electron shells as far as ordinary electrons are considered and behave like noble gases with charge in short scales and do not form molecules. Therefore "monoatomic element" is justified. Of course, only the electrons in the outermost shell could be dark and in this case the element would behave chemically and also look like an atom with smaller atomic number Z. So called Rydberg atoms for which valence electrons are believed to reside at very large orbitals could be actually dark atoms in the proposed sense.

Obviously also ORME is an appropriate term since some valence electrons have re-arranged orbitally. White Gold would be Gold but with dark valence electron. The electron configuration of Gold is $[Xe]4f^{14}5d^{10}6s^1$. There is single unpaired electron with principal quantum number $m = 6$ and this would be dark for White Gold and chemically like Platinum (Pt), which indeed has white color.

Remark:: The precious metals involved are also transition metals near the end point of the group along the row of the periodic table as are also Mott insulators.

The ability of ORMES consisting of single isolated atoms to behave like condensed matter system would be due to the presence of long magnetic flux tubes assignable to valence electrons with large n and connecting the atoms of ORMUS together. For ordinary valence bonds the flux tubes are short and one obtains ordinary metal lattice.

2. Developments at quantitative level began with the TGD based explanation [L48] (see `http://tinyurl.com/y8pqcc8s`) for the finding that in heating of a system involving transition metal unpaired valence electrons mysteriously disappear. The increase of $h_{eff} = n \times h$ for valence electrons in transition metals from their normal value would explain how they become dark matter in TGD sense. Since the binding energy associated with the bond increases with n, energy is required to kick electrons to the dark valence band and heating provides it. In TGD inspired quantum biology, metabolic energy increases the value of n for valence bonds and makes possible quantum coherence in unusually long length scales.

3. This model led soon to a TGD inspired model for valence bonds [L46] (see `http://tinyurl.com/ycg94xpl`). The value of n for valence bond depends on the valence of the atom having larger electronegativity (more towards right along the row of the Periodic Table) and increases as one moves along the row: this guarantees that the bond energies vary only weakly along the row of the periodic table. The simple expectation form ordinary quantum theory is that the dependence of bond energy should be rather strong.

The outcome is a vision about biochemistry and the roles of various valence bonds in metabolism. The valence bonds associated with atoms with high electronegativity carry especially larger metabolic energy identified as the difference of the bond energies for the actual value n_{bond} of n and its value n_{atom} for free atom. Catabolism would liberate this energy by reducing the values of n_{bond}.

Many-sheeted description of conductors

The first question is what electrons and elementary particles are at space-time level in TGD Universe.

1. In many-sheeted space-time elementary particles are two-sheeted structures consisting of two wormhole contacts, whose throats are connected by flux tubes at both sheets. The flux tubes at other sheet defining the magnetic body of the particle could have large value of $h_{eff}/h = n$ and be rather long. For instance, in atomic nucleus the flux tubes connecting nuclei to a nuclear string would be short with length L of order nucleon size but the flux tubes at the sheet defining magnetic body would be considerably longer - naturally given by nuclear length scale [L3, K29]. The length would be even longer for dark nuclei [L43].

2. Many-sheeted space-time predicts a hierarchy of space-time sheets and magnetic fields in various scales would correspond to these sheets and be represented as flux tubes. Flux tubes within flux tubes is what comes naturally in mind. Valence bonds would correspond to flux tubes defining only one level in this length scale hierarchy. Certainly this level is higher than elementary particle level, which corresponds to the Compton size of elementary particle.

3. Valence flux tubes could correspond to the magnetic body of the particle and have large valued of n. In accordance with the TGD view about valence bonds [L46] (see http://tinyurl.com/ycg94xpl) the value of n for valence bonds making possible also conductivity is larger than for free atoms.

   Remark: TGD Universe is fractal and this picture about elementary particles and their magnetic body is very similar to the view about galaxies as knots in long flux tube and having protuberances analogous to the flux loops and containing stars as sub-knots [L63] (see http://tinyurl.com/ybbs9zhp).

   What makes the system a conductor?

1. Suppose that valence bonds indeed correspond to flexible loop like structures, which can be rather long for large values of n. Could the hopping of electrons between neighboring molecules (or atoms) be basically a topological process?

   Could the valence flux loops of neighboring molecules (say NiO) temporarily reconnect to form a pair of flux tubes connecting the molecules so that electrons can propagate along the these flux tubes between molecules?

   There would be no resistance during the flow along flux tube but the stopping at the end of the flux tubes would contribute to the resistance. In absence of electric field the currents are in random direction but the presence of electric field would make possible a net current.

2. One can try to relate this picture also to the standard description of conductivity obtained replacing many-sheeted space-time with that of special relativity so that all information about space-time topology is lost. What remains are the parameters U and t defined as matrix element of ΔU and the gap energy for the conduction band defined as $U - 2zt$.

   A de-localization of electrons occurs in conductivity due to temporary reconnections inducing hopping of electrons between neighboring sites. The increase of n increases various quantum scales. In particular, the length of valence bond increases and the wave functions for valence electrons are de-localized in a larger volume.

   Therefore the matrix elements of ΔU receive contributions from a volume, where ΔU is large. For flux tubes connecting neighboring unit cells it could be even larger than this.

   Also the value of U as expectation value of Coulombic energy for single site is affected. When the value of the competing parameter U becomes large enough, band gap becomes so large that conductivity is lost and one has Mott insulator.

7.11.3 Mott insulators in TGD framework

In TGD framework the new view about valence bonds and anti-ferromagnetism provides new insights about Mott insulators.

1. The valence bonds for oxides such as NiO should have high values of n and for certain critical parameter values (quantum criticality) n might become even higher than for ordinary valence bonds. This would increase the quantum coherence length measured by the flux tubes connecting neighboring molecules: the naïvest guess is that it is proportional to n (for the atomic orbitals it is proportional to n^2). This makes makes possible quantum coherence in longer scales than usually possibly leading to a formation of Cooper pairs implying super-conductivity at least in short scales at low enough temperatures.

2. Transition metal property is essential for being a Mott insulator. The table of Wikipedia article gives an overall view about transition metals (see http://tinyurl.com/ydyqunm4).

There are 4 groups corresponding to the values $r = 4, 5, 6, 7$ labelling the rows of the Periodic Table.

Ni atoms appearing in Mott insulator NiO and Cu atoms appearing in copper oxide high T_c superconductors belong to the group 4 of transition metals, which means that they belong to the fourth row of the Periodic Table (principal quantum number of highest valence electrons equals to 4). Ni and Cu are at the right end of the portion of 4th row containing transition metals. The value of n for copper oxides is predicted by TGD based model of valence bond to be highest in group 4 and second highest for Ni [L46] (see `http://tinyurl.com/ycg94xpl`). Copper oxides are therefore ideal candidates for high T_c superconductors in TGD Universe!

For the groups 5, 6, and 7 the oxides of the elements towards the ends of these rows, in particular those of the rightmost elements in the group are Ag, Au, and Hs are good candidates for high T_c superconductors if the TGD based interpretation makes sense. One can also ask whether T_c could be higher for the transition metals of higher groups.

Remark: ORMEs are precious metals belonging to 5th and 6th groups of transition metals and claimed to be superconducting at room temperatures. Their claimed healthy effects could be due to the large metabolic energy content of the valence bonds involved liberated when utilized.

3. Anti-ferromagnetism is also essential for Mott insulator property besides the property called "mottism" summarized above. Also copper oxides are anti-ferromagnetic (AFM) and the TGD based model relies on the existence of parallel flux tubes carrying magnetic fluxes with same magnitudes but opposite directions [K89, K90]. The members of Cooper pairs are at different flux tubes and form spin singlets.

4. An intriguing property of Mott insulators is the existence of bosonic excitations with charge 2e. They must consist of 2 electrons (see `http://tinyurl.com/ydyqunm4`) and are therefore natural candidates for the precursors of Cooper pairs in unconventional superconductivity.

Transition to non-conventional superconductivity

What could happen in the transition to non-conventional superconductivity?

1. Anti-ferromagnetism is a necessary ingredient. It requires the presence of flattened square shaped flux tube loops with opposite directions of magnetic flux for the opposite sides of the flattened square. Also the flux tubes defining the valence bonds and assignable to the magnetic bodies of electrons are present. The temporary reconnection of the valence flux loops would give rise to ohmic conductivity.

Could the valence flux tubes temporarily reconnect with AFM flux tubes inducing the transfer of electrons to them so that supra current would flow along the resulting flux tube pairs and one would have high T_c superconductivity.

There is however an objection against this idea. Valence electrons are responsible for ferromagnetism: can one really distinguish between the AFM flux loops and valence flux loops. Many-sheeted space-time suggests that this is spossible. AFM loops would correspond to a higher level in the hierarchy of space-time sheets than valence loops do. Cooper pairs reside at these flux tubes whereas Ohmic current carriers reside at the valence loops.

2. How exactly are the Cooper pairs formed? Are they formed as Cooper pairs with members assignable to neighboring lattice sites and are these pairs transferred to AFM flux tube pairs by temporary reconnections? If so, the basic mechanism giving rise to supra current would be purely topological.

As already mentioned, Mott insulators are characterized by the existence of bosonic excitations with charge 2e, which must consist of 2 electrons (see `http://tinyurl.com/ydyqunm4`). This would suggest that they are precursors for the Cooper pairs of high T_c super-conductors appearing below the upper critical temperature T_{c1} but not yet giving rise to superconductivity in long length scales? The transition to superconductivity for Mott insulators would be analogous to the transition to super-conductivity for high T_c superconductors.

3. According to TGD based model of high T_c superconductors [K25, K26, K89, K90] the transition to superconductivity would take place at two steps. At higher critical temperature T_{c1} a phase transition to a state containing Cooper pairs takes place but there is no superconductivity in long scales yet. Supra currents would be associated with AFM flux loops having the shape of a flattened rectangle such that magnetic fluxes have opposite directions at the opposites sides of the rectangle. At lower temperature T_c a phase transition to a genuine super-conductivity takes place: sequences of the flux loops would reconnect to much longer flux loops making possible macroscopic supra currents.

7.11.4 TGD description for the super-conductivity of graphene

The above general model for high T_c super-conductivity and Mott insulators can be applied also to graphene bi-layer.

1. Graphene sheets are hexagonal lattices formed from aromatic rings of 6 C-atoms. Delocalization occurs for valence electrons inside 6-rings and a further delocalization occurs as the hexagonal lattice is formed and gives rise to conductivity. The current flow would be along routes associated with the flux tube network formed from the hexagons. As already explained, in the TGD based model for valence bonds the value of $h_{eff}/h = n$ is higher for valence bonds than for atoms.

2. For the generic twist angle θ the graphene sheets behave like independent conductors with a weak interaction. For critical twist angles the system behaves as a single coherent unit and becomes Mott insulator. The increase of h_{eff} increases the energy of the valence bond increasing band gap so that it becomes difficult to kick electrons to valence band by thermal energy. Conductivity is lost. The increase of quantum coherence length can however lead to a formation of Cooper pairs (as in Mott insulators quite generally) and an applied electric field can kick the electrons to a new conduction band allowing super-conductivity.

3. The critical twist angle can be understood in terms of a generation of lattice like structure with an increased size of the lattice cell. At the nodes of this super-lattice the carbon atoms of two sheets would be directly above each other. The formation of this super-lattice is known as Moire effect (see `http://tinyurl.com/qchunes`).

   Cooper pairs would have periodic wave functions in the superlattice. Wave length would be equal to the lattice constant of the superlattice in the simplest situation. $h_eff/h = n$ view about dark matter would suggest that the members of Cooper pair are dark ($n = n_s$) and that the ratio of the lattice cells sizes for super-lattice (l_s) and the original lattice (l) equals to the ratio of corresponding values of n: $l_s/l_1 = n_s/n$.

4. Precursors of the Cooper pairs should be associated with the combination of flux tube networks defined by the two graphene lattices and would be transferred to AFM flux loops having longer length and reconnecting to long flux flux tube pairs.

   Since superconductivity occurs only for a critical twist angle, a pairing of flux tubes connecting the nodes of the super-lattice should take place. The members of Cooper pair should be associated with members of these flux tube pairs. The distance between Cooper pairs would have upper bound give by l_s.

7.12 Rydberg polarons as a support for TGD view about space-time

I learned about very weird looking phenomenon (see popular article at `http://tinyurl.com/y96p48u5`) involving Bose-Einstein condensate (BEC) of strontium atoms at ultralow temperature corresponding to $T = 1.5 \times 10^{-7}$ K and thus thermal energy of order 10^{-11} eV. Experimenters create Rydberg atoms by applying a laser beam to BEC of strontium atoms: second valence electron of Sr is kicked to at an orbital with very large classical radius characterized by the principal quantum number n. This leads to a formation of "molecules" of BEC atoms inside the orbit of Rydberg

electron - Rydberg polarons as they are called. The term polaron comes from charge separation in the scale of polaron.

It seems strange that a tiny electron would be able to confine BEC molecules inside its orbit. The Rydberg polaron has several counter intuitive properties distinguishing it from ordinary polarons. Skeptic can also ask whether the formation of Rydberg atoms only makes the detection of BEC molecules possible when the atom to become Rydberg atom belongs to an already existing BEC molecule.

7.12.1 Experimental findings

From the research article [D19] (see `http://tinyurl.com/ybqb7bmv`) one learns that the experimenters use in a very clever manner the information about low energy scattering of Rydberg atoms in s and p partial waves to deduce so called Born-Oppenheimer potential (BOP). BOP is analogous to that used in molecular physics to deduce electronic states assuming molecular positions fixed. Now however Rydberg state for electron is fixed and one solves the states of BEC in this potential! The idea is that BEC behaves as a single particle. The objection to this is is that the states are reported to be more like molecules of some BEC molecules containing also the Rydberg atom.

BOP is a combination of $|\Psi_R|^2$ and $|\nabla\Psi_R|^2$ with coefficients proportional to s- and p-wave scattering lengths A_s and A_p (which is momentum dependent) deduced from the low energy scattering of Rydberg atoms from BEC. The explicit expression for the BOP is given as

$$V(r) \quad = \quad \frac{2\pi\hbar^2}{m_e}\left[A_s|\Psi_R|^2 + 3A_p|\nabla\Psi_R|^2\right] \quad . \tag{7.12.1}$$

Here $\Psi(r)$ is the wave function of Rydberg electron. By using rather advanced methods (functional determinant approach (FDA) and mean field theory) the experimenters estimate the bound state energies of BEC atoms in BOP numerically. The bound states would be localized states associated with the minima of the BOP having oscillatory behavior.

The claim is that the experimental findings provide support the existence of these bound states. Usually polarons involve positive energy excitations of the surrounding medium - "cloud" - but now it would be negative energy excitations - bound states - that would be excited. The excitation means that energy is drawn from BEC by dropping some particle to negative energy state: this would be an analog of metabolism.

One can test this proposal experimentally by using two laser beams with frequencies 689 nm and 319 nm. The first beam generates intermediate excitations $5s^2 \rightarrow 5s5p^3P_1$ and latter beam the Rydberg excitations $5s5p^3P_1 \rightarrow 5snp^3S_1$. The frequency of 319 nm beam must be varied to cover the excitations corresponding to various values of n. Since the dependence of the bound states energy is of form $1/n^2$, a rather slight variation is enough to cover a wide range of values of n. One obtains peaks corresponding to various values of n.

The peaks labelled by n have however sub-structure. One can vary the beam frequency slightly downwards from the frequency $\nu_R(n)$, which generates free Rydberg atom. For given n one finds spectral peaks at lower frequencies $\nu = \nu_R(n) - \Delta\nu$. The data is expressed in terms of function $A(\nu)$ telling the intensity of the absorption of laser photons at given frequency ν, and one can estimate binding energies from the values of $\Delta E = h\Delta\nu$. For $n = 38$ $\Delta\nu$ is in the range $[1, 40]$ MHz so that the binding energies ΔE are in the range $[1, 40] \times .4 \times 10^{-8}$ eV. The peak gets narrower for larger values n scaling like $1/n^3$ suggesting that the values of $\Delta\nu$ scales like $1/n^3$.

Remark: This is true for the ordinary value of Planck constant. For non-standard value $h_{eff}/h = n$ of Planck constant the estimate for the binding energies $\Delta E = h_{eff}\Delta\nu$ would be scaled up. This would mean that also the beam energy is scaled up and this looks unrealistic. Since the temperature is extremely low, large $h_{eff}/h = n$ is not needed for macroscopic quantum coherence. Indeed, the thermal wavelength $\sqrt{1/2m_eT}$ of electron giving an idea about the scale of spatial quantum coherence is at the temperature considered of order 100 μm.

Fig. 2 of the article (see `http://tinyurl.com/ybqb7bmv`) shows for $n = 38$ clearly the peaks at multiples of -5 MHz corresponding to $\Delta E = -2.1 \times 10^{-8}$ eV for the corresponding energy interpreted as binding energy rather than positive excitation energy in the initial state. The appearance of integer multiples suggests that harmonic oscillator excitations involving one or several oscillators are in question. What looks strange that the spectrum of excitations has negative

rather than positive energies. The finding is interpreted as a direct evidence for the existence of BEC molecules - Rydberg polarons predicted by the model based on scattering length data. For a small number of BEC atoms one can even study the molecules.

Remark: The analogy with harmonic oscillator spectrum leads to ask whether a genuine harmonic oscillator spectrum with positive excitation energies could be in question - say cyclotron energy spectrum for electrons in an external magnetic field B_R assignable to the pair of s-wave electrons of Rydberg atom and having therefore positive excitation energies. The interpretation would be in terms of the analog of metabolism analogy also now. The excited Rydberg atom would drop some BEC atoms to lower energy state and in this manner extract energy from BEC.

Authors report several features distinguishing the Rydberg polaron from ordinary polaron. Ordinary polaron corresponds to a ground state of a many-particle system but now one has multiple excitations from the ground state. Also the importance of bound states would distinguish Rydberg polaron from ordinary polarons. A universal behavior of the spectral line shape decreasing like $1/n^3$ as a function of principal quantum number characterizing the Rydberg electron suggests that quantum criticality. Also the narrowing of the spectral features with n is reported.

In the model of experimenters the binding energy spectrum depends on the value of the principal quantum number n since the positions of zeros of $V(r)$ depend on n. Since $V(r)$ is product of exponent function and polynomial of order $2n$, $dV(r)/dr$ has at most $2n-1$ real zeros and at most n minima. One expects that harmonic oscillator strength has different values for these zeros, which also depends on n. One obtains in harmonic oscillator approximation integer multiples of the basic energy depending on the minimum of $V(r)$.

On basis of the article, I am not able to tell whether the authors have any concrete model for what the assumed (effectively contact -) interaction between the Rydberg atoms and BEC atom is. What this interaction is and how it leads to a generation of bound states (not necessarily!) in the case of BEC atoms but not in the case of ordinary atoms, remains a mystery to me. The question whether TGD might provide some ideas about in this respect, served as the basic motivation for the following considerations. This led to a considerably more detailed understanding about how TGD differs from Maxwellian electrodynamics.

7.12.2 Could TGD say something interesting about Rydberg polarons?

The obvious question in TGD framework is whether this mysterious interaction giving rise to the BEC molecules (or whatever they are) could be understood using the notions of many-sheeted space-time, magnetic flux quanta, and possibly also the identification of dark matter as phases of ordinary matter with non-standard value of $h_{eff}/h = n$.

Some applications of TGD view about space-time

I have applied this general rule in various scales with inspiration coming from the fractality of TGD Universe.

1. Elementary particles correspond in TGD pairs of wormhole contacts connected by flux tubes at both space-time sheets involved. Hadrons involve color flux tube structures carrying most of the energy of the hadron [K64, K71, K72].

2. Atomic nuclei and their dark variants explaining "cold fusion" are nuclear strings [L27, L43]. Dark nuclear strings are also in central role in TGD inspired quantum biology [L55] and their states are in correspondence with DNA, RNA, tRNA, and amino-acids [L34].

3. In TGD based view about chemistry valence bonds correspond to flux tubes with non-standard value of $h_{eff}/h = n$ [L46]. In biology valence bonds are carriers of metabolic energy with n measuring the amount of metabolic energy and increasing along the row of the Periodic Table. The model conforms with empirical facts and explains why the molecules towards the right end of the rows of the Periodic Table are carriers of metabolic energy.

4. Superconductivity and superfluidity are natural applications [K37, K38, K39, K40, K83]. Flux tubes would serve as correlates for the correlation of the members of Cooper pair. In high T_c superconductivity supra currents flow along the flux tubes [K89, K90].

5. In neuroscience and biology the quantum entangled networks of neurons and cells define the correlates of mental images at the level of brain and body and also the part of magnetic body outside biological body is in central role [L42, L61]. Gravitational and other interactions are mediated along flux tubes and here the notion of gravitational (electromagnetic, etc) Planck constant is very useful [K104, K81, K83]. The notion of gravitational Planck constant $h_{eff} = h_{gr}$ is assignable to the flux tubes mediating gravitational interaction and having very large value is involved also with TGD inspired quantum biology and neuroscience [K20, K30].

6. At the second end of the scale hierarchy there is a model for the formation of galaxies as knots of long flux tubes carrying dark energy and dark matter and having stars as sub-knots of these knots. Second example is nuclear physics and its dark variants.

What guidelines to follow?

The listed successful applications encourage to ask whether the TGD could provide a model for Rydberg polaron. There are several guidelines to follow.

1. The key question concerns the role of Rydberg atom. Does its formation lead to the generation of Rydberg molecules or are they already present in BEC. The mechanism for the formation of the Rydberg molecules depends crucially on the answer to this question. If Rydberg atom is necessary, the magnetic field induced by the formation of Rydberg atom could be crucial for understanding what happens. This would also force the intepretation about the role of bound states unless the arrow of geometric time changes temporarily in the process. If Rydberg atom is not necessary, then alternative options can be considered.

2. The notion of cyclotron BEC as a condensate of cyclotron states of charged bosons or Cooper pairs playing important role in TGD inspired biology is of special interest since it could explain the appearance of excitation energies as basic energy identifiable as cyclotron energy. The BECs of electron Cooper pairs and of biologically important ions or their Cooper pairs are central in TGD based of quantum biology and neuroscience. What is encouraging that the energies identified as bound state energies have scale assignable to cyclotron states in magnetic field which is roughly $3.3 \times B_E$, where $B_E \simeq .5$ Gauss is the nominal value of the magnetic field B_E of Earth.

   Remark: The strength of B_E varies in the range $[.25, .65]$ Gauss and one cannot exclude the possibility that $B_{end} = .2$ Gauss corresponds to minimum value of B_E achieved at equator. In dipole approximation the strength at poles is two times higher.

3. One can of course argue that the introduction of an external magnetic field is unrealistic. I do not know whether this is the case: dark magnetic fields would not be observable using the detection methods of standard physics. On the other hand, the origin of B_{end} has remained a mystery. Could its flux tubes connect charged particles of opposite spin so that B_R and B_{end} would accompany essentially same physical phenomenon?

4. The analogy with metabolism suggests the possible relevance of zero energy ontology (ZEO) leading to the proposal of what I call remote metabolism involving temporary reversal of the arrow of time at some level of the hierarchy of space-time sheets labelled by preferred p-adic primes and values of n and making possible for the system to extract energy from environment in apparent contradiction with the second law.

   In the recent case the problem is that one would expect that the energy of laser photon is shared between the Rydberg atom and other BEC atoms. Just the opposite happens. One might argue that this is not a problem since temperature is so low but I am not certain about this. There is also a second problem: if B_R is responsible for the cyclotron states, then the only sensible interpretation is that the arrow of geometric time is temporarily changed since before its cyclotron BEC providing the "metabolic energy" is not present.

   In ZEO "big" state function reduction behind TGD inspired theory of consciousness means temporary reversal of arrow of time for the entire system [L53]. Conscious entity as a generalized Zeno effect in turn would correspond to a sequence of ZEO analogs of weak measurements and dying when the big reduction takes place.

What looks for the observed with standard arrow of time like extraction of metabolic energy from BEC would correspond to sharing it with BEC if the arrow of time changes temporarily. This might relate to the finding that the entanglement between electrons of Sr^+ ions lasts surprisingly long time - 15 seconds. Could this time correspond to the duration of the time reversed state.

5. A further possible guideline comes from the general vision replacing many-particle states with tensor networks [L38] having particles as nodes connected by magnetic flux tubes carrying magnetic flux (possibly monopole flux). The general rule is that if there is quantum correlation/entanglement, it has flux tube as a space-time correlate. The model for valence bond based on $h_{eff}/h = n$ hierarchy could help here although the fact that valence bonds are between atoms with opposite electro-negativities suggests that this is not a correct guide line to follow.One can however ask whether Cooper pair as spin singlet bonded by flux tube might replace the valence bond.

   One can imagine several options.

1. The energy scale of the excitations is very low suggesting that magnetic interaction energies are in question. Since Sr atoms have vanishing nuclear magnetic moment, the magnetic field generated by the two s-wave electrons of the Rydberg atom could serve as candidate for this external magnetic field. In Maxwellian framework this option fails but in flux tube picture for the magnetic field created by the electrons the situation changes as already briefly described in the interoduction.

2. Could the formation of Rydberg molecules (or whatever they might be) be due to a formation of flux tube contacts between BEC atoms serving as analogs of valence bonds. An immediate objection is that in chemistry valence bond is between states of opposite electronegativity. Pairing might however occur by spin-spin interaction.

   Now Maxwellian expression for the magnetic spin-spin interaction energy varies in a range involving 9 orders of magnitude and for the average distance of order .1 μm it is several orders of magnitude too low. This means a loss of predictivity. One could imagine for instance a molecule of 3 BEC atoms ABC in which the distances between A and B and A and C would be different: this would give a non-trivial binding energy. Again Fermi statistics is a problem: it seem very difficult to avoid p-wave excitations of electrons.

   Flux tubes distinguish TGD microscopically from Maxwell's theory. Could flux tubes be generated between the s-wave electrons of different BEC atoms. Also now the net interaction energy tends to cancel by statistics constraints in Maxwellian approach. TGD based model of superconductivity suggests a solution of the problem: the two s-electrons are condensed at different flux tubes and the spin-spin interaction between them gives rise to binding energy or at least binds them to Cooper pair (strontium-titanate is super-conductor!).

3. TGD inspired quantum biology suggests the most promising approach found hitherto. An external magnetic field would be present: either the Earth's magnetic field B_E with nominal value of .5 Gauss (experimental arrangement might eliminate B_E) or its "endogenous" dark variant with a nominal valued $B_{end} = 2/5B_E = .2$ Gauss possibly characterized by $h_{eff}/h = n > 1$. Actually B_{end} has spectrum of strengths in TGD inspired quantum biology and explains bio-photons as ordinary photons resulting from dark photons in the transition $n > 1$.

   The model of authors could be perhaps understood in terms of negative magnetic dipole interaction energy of electrons with this magnetic field. The two electrons in s^2 state would topologically condense at flux tubes with opposite magnetic fluxes and could have negative spin-spin interaction energy binding them to a Cooper pair. There is however a problem: the shape of the spectral peak depends on the principal quantum number n suggesting that the value of the magnetic field involved behaves like $B \propto 1/n^3$.

   Skeptic of course argues that the introduction of external magnetic field is a desperate last attempt before giving up. The origin of B_{end} has however remained a mystery. Could it be that B_R and B_{end} are aspects of the same phenomenon? If so then also the $B \propto 1/n^3$ dependence could be understood.

4. An alternative model gives up the assumption that bound states are in question but allows temporarily time reversal. cyclotron excitations of the BEC condensate containing electrons of the BEC atoms still experiencing the Coulomb force would be in question. Magnetic field with strength $3.3 \times B_E \simeq 8B_{end}$ could explain the frequency spectrum quantitatively as cyclotron energy spectrum so that instead of bound states one would have positive energy states but the metabolic analogy would still apply.

Brief summary of TGD based model

TGD inspired model is based on a more detailed model for flux tubes.

1. The strength of the constant valued flux tube magnetic field B_R associated with the flux tube model of electron plays the role of the physical dipole as a region of constant magnetization associated with a real world dipole field. The flux tube carries a monopole flux made possible by CP_2 topology so that the Maxwellian counterpart does not exists for it. This view about dipole magnetic field is a signature of many-sheeted space-time.

2. One can model the quadrupole field B_R associated with two-sheeted closed flux tube connecting 5s and ns electrons of Rydberg atom. In Maxwellian theory B_R would vanish along the line between the dipoles but in TGD it has opposite directions at parallel (essentially same M^4 projection) space-time sheets so that it vanishes only at QFT limit. The members of BEC s^2 electron pairs topologically condense at separate flux tube sheets to minimize the magnetic interaction energy associated with their spins. This mechanism could also give rise to Cooper pairs. Negative energy spectrum could correspond to a generation of several electron pairs in energy minimum.

3. B_R gives rise to the analog harmonic oscillator potential with ground state energy defined by the interaction energy of spins with B_R. If B_R depends on the distance L between the s-wave electrons of the Rydberg atom in a universal manner $B_R \propto 1/L^{3/2}$, one can understand the universal $1/n^3$ dependence of the width of the observed peak.

   The distances associated with the maxima of $|\Psi|^2$ give sub-peaks defining preferred Larmor frequencies so that the structure of the peak gives a map of $|\Psi(r)|^2$. If Rydberg atom moves with respect to BEC, one must add the p-wave contribution just like one does in the model of authors and find maxima for this. The basic difference with respect to the BOP approach of experimenters is that one has maxima rather than minima.

4. ZEO allows also to consider the possibility that the arrow of time is temporily changed in the state function reduction creating the Rydberg atom: this interpretation would allow the excitation of cyclotron states with reversed arrow of time. For an observer living in standard direction of time the process would look like dropping cyclotron electrons to lower energy states to get surplus energy so that the laser photon energy need be so high. This would give harmonic oscillator spectrum for each electron pair behaving like Cooper pair. It should be easy to experimentally test for the correctness of the two proposals.

7.12.3 Maxwellian and TGD pictures for the magnetic interaction energy

TGD suggests that the proper way to model the spin-spin interaction is to use the flux tube picture. Maxwellian approach provides a second approach and one might hope that it could give a reasonable approximation.

Maxwellian approach

QFT limit of TGD with flux tubes replaced with Maxwellian magnetic fields is expected to give a good approximation of electromagnetic interactions. Therefore it is realistic to start from a Maxwellian picture for the electromagnetic fields. If Maxwellian picture gives reasonable order of magnitude estimates one can hope that also the TGD view based on the notion of magnetic body (MB) does so.

1. The obvious idea is that the magnetic field in atom is created by the total electron current of electrons. In particular, valence electrons give to this kind of current via Maxwell's equations: $\nabla \times B = j_e/4\pi$. This would give connection between electron current and B analogous to that appearing in BOP where modulus squared for electron's Schrödinger amplitude and its gradient appear.

   This picture applies also Coulomb interaction: now the charge density of electrons would serve as the source of electric field via $\nabla \cdot E = \rho$.

2. The two electrons of Sr Rydberg atom create a magnetic field, call it B_R. Same applies to the valence electrons of s^2 state of BEC atom. In the first approximation the magnetic moment of the unexcited electron determines the magnetic field at large distances. Since the electron's wave functions depend on the radial coordinate only in s-wave, the current $\bar{j}_e$ due to the gradient of Ψ is radial for both electrons. One can reduce the equation $\nabla \times \overline{B} = \bar{j}_e/4\pi$ to a Laplace equation by using $\overline{B} = \nabla \times \overline{A}$ and Coulomb gauge $\nabla \cdot \overline{A} = 0$. This gives $\nabla^2 \overline{A} = \bar{j}_e \equiv j\overline{r}/4\pi$.

   Besides this there is a contribution due to the spin of the electron and in the direction of spin projection for spin eigenstates. In the lowest order approximation the $n = 5$ electron looks like point-like magnetic dipole and generates dipole field. Same in principle applies also in the case of s^2 state of two electrons and also in case of electrons inside [Kr] shell (the electronic configuration of Sr is [Kr]s^2).

   I do not know whether the above approach has been proposed earlier. In any case, it could be motivated by the following argument.

1. Also the electrons of BEC atom have spin-spin interaction and the first thing that comes into mind is to estimate its contribution to the energy by taking expectation value in the two fermion state defined by s-wave valence electrons. If the pair of s^2 electrons transforms a Cooper pair, one must be able to estimate the change in energy, in particular spin-spin interaction energy.

2. If found no mention about spin-spin interaction in web but found a popular article telling that the measurement of the spin-spin interaction energy is extremely difficult but was carried for a pair of Sr^+ ions (!) at distance of order 2 μm (see `http://tinyurl.com/yasjvufz`): this would partially explain why it has not been calculated. It was also found that the coherence time for entangled electron pair was unexpectedly long: 15 seconds.

   In the popular article the calculation of the effect was mentioned to be very difficult. The repulsive interaction between fermions gives a competing contribution which - being expectation of $1/|r_1 - r_2|$ - is finite. As a matter of fact, I realized that the integral defining the expectation value of $1/|r_1 - r_2|^3$ appearing in the expectation value of spin-spin interaction energy in s-wave state in two fermion state diverges logarithmically!

   The pragmatic way out of the difficulty would be straightforward: do not try to calculate anything giving an ill-defined answer! To gain more respectability for this view one could formulate the state of affairs as a general rule. One is allowed to estimate only the effects of external fields - say that of nucleus when calculating spin-orbit interaction energy or interactions between atoms - by using this approach. The external field depends in this case on the electron configuration involved so that one cannot regard spin-spin interaction as being due to an external magnetic field.

   Atomistic skeptic can however argue that in Born-Oppenheimer approach assumes the configuration of atoms to be given and calculates electron states associated with this and then solves Schrödinger equation for the atoms. Also in the calculation of color-magnetic spin-spin splitting of mesons and baryons this approach is used. Therefore the problem is real and one must solve it.

   The proposed approach could however allow to get rid of the divergence associated with spin-spin interaction since the magnetic field determined by the total current defined by electrons gives smoothed out magnetic field free of singularity associated with point-like magnetic dipole.

How flux tubes as mediators of magnetic spin-spin interaction would relate to the Maxwellian picture?

In TGD based approach flux tubes would mediate the magnetic interaction. For two different atoms electrons would be connected by flux tubes and the electrons at its end or possibly moving freely in the interior would interact with essentially 1-D magnetic flux. This picture could apply also to electrons inside single atom. Also Coulomb interaction energy could be estimated in the same manner between electrons of single atom. In the case of separate atoms one can argue that repulsive Coulomb interaction can be neglected in excellent approximation.

  Remark: Strong form of holography (SH) implies that at least in the sense of information theory electrons at space-time level can be thought of as being localized at 2-D string world sheets - that is electron states are fixed by 2-D data. In this picture flux tubes are accompanied by fermionic strings with fermions at their ends assignable to the light-like orbits of partonic 2-surfaces at which the signature of the induced metric changes from Minkowskian to Euclidian. At the level of embedding space $M^4 \times CP_2$ the spinors characterizing ground states of super-conformal representations are however 8-D and it is these spinors that correspond to those of standard model.

  One must have rules for how to replace Maxwellian field with flux tubes.

1. Flux tubes carry a conserved magnetic flux. Therefore the magnetic field is essentially constant inside flux tube and the situation is effectively 1-dimensional. One can consider also the possibility that the magnetic flux is quantized. In TGD framework it is also possible to have closed flux tubes carrying monopole flux looking locally like pair of flux tubes with opposite fluxes: they could appear in super-conductors and in cosmology. No currents are needed to create these magnetic fields made possible by the topology of CP_2. The cross section of this kind of flux tube is closed 2-surface rather than a disk with holes. For these flux tube pairs Maxwellian limit does not exist.

2. Flux conservation implies that the spin-spin magnetic interaction energy for given flux tube does not depend on distance.

3. There is a distribution of magnetic flux tubes, which should correspond to the Maxwellian field. The intuitive picture is that the density dn/dS of flux tubes normal to given 2-surface having normal direction $\overline{n}$ multiplied by possibly quantized magnetic flux corresponds to the value of Maxwellian magnetic field:

$$\overline{B} \leftrightarrow \frac{dn}{dS} \Phi \overline{n} \ . \tag{7.12.2}$$

   dn/dS would be determined by the wave function for 3-surfaces in the "world of classical worlds" (WCW). This picture would hold true at larger distances from the source - say dipole.

4. Flux tubes field could mimic Maxwellian field with a better accuracy if the flux tubes can branch at larger distances. This would look natural for dipole fields. The outcome be a kind of fractal tree like structure growing in the radial direction. This would involve reduction of the field strength and possible also the net flux which could be large in the vicinity of dipole but reduce later.

  This picture generalizes to electric flux tubes/quanta carrying constant electric flux. By effective one-dimensionality the electric potential is proportional to distance along flux tube.

  Interesting questions relate to the possibility of space-time sheets parallel in $M^4 \times CP_2$ and having same M^4 projection: at QFT limit they are replaced region of M^4 with deformed metric.

1. One can imagine that both valence electrons with opposite spins are accompanied magnetic flux tubes such that they correspond 4-surfaces on top of each other and extremely near to each other in $M^4 \times CP_2$ such that the magnetic fluxes are in opposite directions but of the same magnitude. At QFT limit the total magnetic field would vanish on test particle if it touches all parallel sheets and experiences the fields from all of them.

2. Consider a situation involving two magnetic flux tubes as different sheets associated with spins in opposite directions so that magnetic fluxes are opposite at them. One can imagine a deformation implying that space-time sheets at not at top of each other. Now the magnetic spin-spin interaction would be non-trivial in these regions and favor the formation of bound state spin singlet identifiable as Cooper pairs. Could energy minimization favor the formation of pairs of this kind of single-sheeted regions? For instance, the formation of groups of BEC atoms connected by flux tubes could involve this mechanism. In the situation when the flux tubes project to same region of M^4, bound states would not be possible.

What could happen when the Maxwellian approach fails?

To understand the flux tube picture and connect with with the Rydberg polaron, it helps to ponder what happens when the Maxwellian approach fails. For the magnetic dipole field the region near the locus of the dipole represents a situation, where Maxwellian description might indeed fail. One can take the TGD inspired model of electron itself as a starting point.

1. Electron (actually any elementary particle) would be a pair of wormhole contacts (I and II with throats I1,I2 and II1,II2) connecting two space-time sheets with electron at the throat I1 of contact I and left-handed neutrino ν_L at throat II1 and right-handed neutrino $\bar{\nu}_R$ at throat II2 of contact II. The flux tubes would carry monopole magnetic flux flowing also through the contacts and stabilizing it: otherwise the space-time sheets would only touch for some time.

    In scales shorter than the length L of the flux tubes electron would have also weak isospin. At longer scales electron would effectively have only em charge just as standard model predicts.

2. The flux tubes at given space-time sheet would be a correlate for the dipole assigned with dipole magnetic field and carry a constant flux. This corresponds to constant magnetization for a non-ideal dipole created by an inductance in circuit theory.

    Now no current is needed to create the constant magnetic field since monopole flux is in question and the cross section of flux tube is a closed 2-surface. The absence of the current corresponds to the fact that electron's magnetic moment is due to spin and is not created by a current. Monopole flux tube would however give a space-time correlate for the dipole created by spin.

    The strength of the magnetic field would be proportional to $1/S$, S the area of the flux tube projection in M^4. Magnetic dipole would be effectively a pair of magnetic charges (TGD does not however allow isolated magnetic charges) made possible by the topology of CP_2. For non-standard values of h_{eff} these dipoles could have even macroscopic sizes. Monopole fluxes could explain even the mysterious existence of long length scale magnetic fields in cosmological scales.

7.12.4 A model for Rydberg polaron

The proposd picture for spin dipoles allows to imagine a concrete model for the quadrupole type magnetic field created by a pair of s-wave electrons taken far apart as in the formation of Rydberg atom. This model applies also to Cooper pairs and perhaps even to s^2 pairs of electrons in atom.

1. What happens when one has two electrons identifiable as dipoles with opposite spins as in the case of Rydberg atom? Suppose that the spins are oriented along the connecting line. In the region between electrons the magnetic field vanishes in the Maxwellian world. In many-sheeted space-time it is enough that the magnetic fields have opposite direction but exist as induced magnetic fields at parallel space-time sheets. At QFT limit the field vanishes as sum of these fields.

    One could imagine the following model for the resulting magnetic field. The monopole flux tube pairs associated with electrons would reconnect to a single flux tube pair so that the wormhole throats carrying ν_L and $\bar{\nu}_R$ disappear and $\nu_L\bar{\nu}_R$ pairs at throats opposite to electron carrying throats to take care about the vanishing of weak isospin at longer length scales correlating with the massivation causing the short range of weak forces. The magnetic

fields at the opposite throats of both wormhole contacts would have opposite values and at QFT limit the total magnetic field would vanish. This effect is not possible in Maxwellian electrodynamics.

2. The magnetic field would be constant at the flux tubes and equal to $eB = \Phi/S$, $\Phi = BS = n$. One can imagine a topological condensation of the BEC atoms at this flux tube pair. The s^2 electrons of BEC atom would condense at different flux tubes to minimize their magnetic interaction energies $E = -\mu_e \times B$, $\mu_e = e\hbar/2m_e$. Maybe this kind of process could produce the Rydberg polaron.

3. What would be the dependence of the surface area S of the flux tube on the distance L between the electrons? The naïve guess that B has dependence $B \propto 1/L^3$ classically would give $S \propto L^3$. This does not make sense as detailed checks demonstrated.

   If I have interpreted correctly the findings about Rydberg atom, the spectral width as the width of absorption spectrum as function of frequency becomes narrower and scales down as $1/n^3$: the experimenters talk about universality. The $B \propto 1/n^3$ scaling of the magnetic interaction energies would explain this. If the magnetic interaction energies are responsible for the observed spectrum then the proportionality of the size scale of Rydberg atom to n^2 would require $S \propto L^{3/2} \propto n^3$. For $n = 38$ one has $\Delta f = -5$ MHz. This gives the rough estimate

   $$\frac{\mu_B \Phi}{S(n=38)} == \frac{\mu_B \Phi}{\pi R^2(n=5)}(\frac{5}{38})^3 = 2.1 \times 10^{-8} \ eV \ .$$

   This condition fixes the radius $R(n=5)$ of the flux tube at distance $L(n=5) \sim 6.3$ Angstrom to be $R \simeq 10^4 a_0 \simeq .5\ \mu$m. More generally, the basic length scales of biology might be hidden to many-sheeted atomic physics.

4. One could hope that this dependence of S on the distance L between electrons of opposite spin with the line connecting the electrons serving as quantization axis is universal. Could this idea have some explanatory power?

   In TGD inspired quantum biology one encounters the notion of endogenous magnetic field $B_{end} = 2/5B_E$, which is roughly by factor $x = 1/7.5 \sim 2^{-3}$ weaker than $B(n = 38)$. As a matter of fact, B_{end} must have spectrum reflected directly in the spectrum of bio-photons in visible and UV [K20, K30] and in the spectrum of audible frequencies [K91]. The origin of this magnetic field has remained a mystery. Could it correspond to a magnetic field associated with a flux tube connecting electron dipoles with opposite directions at distance L_{end}?

   The proposed model would give the factor

   $$x = \frac{S(38)}{S} = (\frac{L(38)}{L_{end}})^{3/2}$$

   allowing to estimate corresponding distance L_{end} between electrons as

   $$L_{end} = x^{-2/3}L(38) = 4 \times L(38) = (\frac{38}{5})^2 L(5) \simeq 231 L(5) \ .$$

   Assuming that Sr atom behaves for $n = 5$ state like hydrogen atom with effective nuclear charge $Z_{eff} = 2$ (screening would be due to [Kr] shell), one obtains a rough estimate for $L(5)$ would be $5^2 a_0/2 \simeq 6.3$ Angstrom. This would give $L_{end} \sim 1.5\ \mu$m. It is encouraging that this corresponds to the p-adic length scale $L(169) \simeq 1.5\ \mu m$ assignable to cell nucleus size. Note that the p-adic length scale $L(167) = 2.5\ \mu m$ corresponds to Gaussian Mersenne $M_{G,n=167} = (1 + i)^n - 1$.

   The factor 2 would suggest that the B_{end} corresponds to Rydberg atom with $n = 2 \times 38 = 76$. This is only a rough estimate: the estimate for $L(5)$ assumes hydrogen-like atom and this assumes is only approximate since the s^2 electrons spend considerable time inside [Kr] shell which tends to reduce the radius $L(5)$. An interesting question concerns the identification of

Rydberg atom(s) possibly responsible for the generation of B_{end}. The spectrum for $B_{end}(n)$ would be of form $1/n^3$. For given n there would br a spectrum along the n:th row of Periodic Table.

Spin-spin interaction energy at temperature of 1.5×10^{-11} eV would correspond to an energy which is by a factor 10^{-3} lower than that associated with $L(n = 38)$. This corresponds to the scaling $n \to 10n$ and $L(38) \to 100L(38)$.

5. In the realistic situation the Rydberg electron has wave function Ψ. $|\Psi|^2$ has several maxima and minima which correspond to zeros for a polynomial closely related to the square of Laguerre polynomial and having degree $2n$ so that the number of real maxima would be at most $n - 1$. One would have a quantum superposition of also flux tube pairs with different lengths L.

   The flux tube lengths L associated with the maxima would be visible as peaks in the absorption spectrum. One would have peaks at the corresponding Larmor frequencies (and possibly also cyclotron frequencies if temporary time reversal takes place). This picture includes only s wave scattering length and the reason would be that one indeed has pure s-wave electrons.

   The BOP of authors includes also a term proportional to p-wave scattering length: one must adds to Ψ a term proportional to the gradient of Ψ representing the change of the wave function due to the motion. When the Rydberg atom moves with respect to BEC, the wave function has also p-wave component and the scattering length A_p is indeed momentum dependent going to zero at the limit of vanishing momentum. If one can neglect the cross terms proportional to $p \cdot (\overline{\Psi}\nabla\Psi + c.c)$ one obtains the BOP. It therefore seems that TGD might be able to explain the basic properties of the Rydberg polaron.

To sum up, Rydberg polaron could provide a clearcut evidence for the notions of many-sheeted space-time, flux tube, and ZEO and also allow to assign "endogenous" magnetic fields to Rydberg atoms.

Acknowledgements

Chapter 8

TGD Based View about Classical Fields in Relation to Consciousness Theory and Quantum Biology

8.1 Introduction

In TGD Universe gauge fields are replaced with topological field quanta. Examples are topological light rays, magnetic/electric flux tubes and sheets, and flux quanta carrying both magnetic and electric fields. Flux quanta form a fractal hierarchy in the sense that there are flux quanta inside flux quanta. It is natural to assume quantization of Kähler magnetic flux. Braiding and reconnection are the basic topological operations for flux quanta.

The basic question is how the basic notions assigned with the classical gauge and gravitational fields understood in standard sense generalize in TGD framework.

1. Superposition and interference of the classical fields is very natural in Maxwell electrodynamics and certainly experimentally verified phenomena. Also the notion of hologram relies crucially on the notion of interference. How can one describe the effects explained in terms of superposition of fields in a situation in which the theory is extremely non-linear and all classical gauge fields are expressible in terms of CP_2 coordinates and their gradients? It is also rather clear that the preferred extremals for Kähler action decompose to space-time regions representing space-time correlates for quanta. The superposition of classical fields in Maxwellian sense is simply impossible.

   How can one cope with this situation? The answer is based on simple observation: only the *effects* caused by classical fields superpose. There is no need for the fields to superpose. Together with the notion of many-sheeted space-time this leads to elegant description of interference effects without any need to assume that linearization is a good approximation. Charged particles have topological sum contacts to several space-time sheets and experience the sum of the effects caused by the classical fields at all space-time sheets involved.

   Tis picture allows also to understand how the many-sheeted space-time gives rise to effective space-time of GRT when sheets are collapsed to single sheet and metric replaced with sum of Minkowski metric and deviations of induced metrics of sheets from Minkowski metric. Gauge potentials are defined in an analogous way. Equivalence Principle in Einstein's form follows from Poincare invariance.

2. Topological quantization brings in also braiding and reconnection of magnetic flux tubes as basic operations for classical fields. These operations for flux tubes have also Maxwellian counterparts but for field lines and do not play so important role. Braiding and reconnection are however in a central role in TGD Universe and especially so in in TGD inspired theory

of consciousness and quantum biology [K5]. Also 2-braiding in 4-D space-time is possible generalizes the quantum computation paradigm. The challenge is to build a coherent overall phenomenological view about the role of topologically quantized classical fields in biology and neuroscience.

For instance, the notion of conscious hologram [K23] is key concept in TGD inspired theory of consciousness, and the challenge is to formulate this notion more precisely. One can can ask whether the presence of magnetic flux tubes connecting two systems could serve as a correlate of entanglement - or at least negentropic entanglement suggested by the number theoretic vision to be a basic signature of living matter.

3. Topological quantization and the notion of magnetic body are especially important in TGD inspired model of EEG [K106]. The attempt to understand the findings of Persinger from the study of God helmet (see `http://tinyurl.com/3cpoyq`) [J1, J114, J7] leads to a considerable progress in the understanding the possible role of topologically quantized classical fields in biology and neuro-science. In neurotheology the goal is to understand neurological aspects of spiritual experiences and near death experiences (see `http://tinyurl.com/yj523z`) [J9] (NDEs) and out-of-body experiences (see `http://tinyurl.com/2j342h`) [J2] [K110] are challenges for this approach. A good candidate for "God" as it appears in these experiences is magnetic body, perhaps a new leayer added to the personal magnetic body during the experience. This explains also the paradoxical Brahman=Atman experience. TGD indeed predicts infinite hierarchy of selves with entire Universe at the top so that TGD view is not in conflict with the basic ideas of religion.

The appendix of the book gives a summary about basic concepts of TGD with illustrations. Pdf representation of same files serving as a kind of glossary can be found at `http://tgdtheory.fi/tgdglossary.pdf` [L18].

8.2 Comparison Of Maxwellian And TGD Views About Classical Gauge Fields

In TGD Universe gauge fields are replaced with topological field quanta. Examples are topological light rays, magnetic flux tubes and sheets, and electric flux quanta carrying both magnetic and electric fields. Flux quanta form a fractal hierarchy in the sense that there are flux quanta inside flux quanta. It is natural to assume quantization of Kähler magnetic flux. Braiding and reconnection are basic topological operations for flux quanta.

One important example is the description of non-perturbative aspects of strong interactions in terms of reconnection of color magnetic flux quanta carrying magnetic monopole fluxes [K49, K71]. These objects are string like structures and one can indeed assign to them string world sheets. The transitions in which the thickness of flux tube increases so that flux conservation implies that part of magnetic energy is liberated unless the length of the flux quantum increases, are central in TGD inspired cosmology and astrophysics. The magnetic energy of flux quantum is interpreted as dark energy and magnetic tension as negative "pressure" causing accelerated expansion.

This picture is beautiful and extremely general but raises challenges. How to describe interference and linear superposition for classical gauge fields in terms of topologically quantized classical fields? How the interference and superposition of Maxwellian magnetic fields is realized in the situation when magnetic fields decompose to flux quanta? How to describe simple systems such as solenoidal current generating constant magnetic field using the language of flux quanta?

8.2.1 Superposition Of Fields In Terms Of Flux Quanta

The basic question concerns the elegant description of superposition of classical fields in terms of topological field quanta. What it means that magnetic fields superpose.

1. In Maxwell's linear theory the answer would be trivial but not now. Linear superposition holds true only inside topological light rays for signals propagating in fixed direction with light velocity and with same local polarization. The easy solution would be to say that

one considers small perturbations of background space-time sheet and linearizes the theory. Linearization would apply also to induced gauge fields and metric and one would obtain linear superposition approximately. This does not look elegant. Rather, quantum classical correspondence requires the space-time counterpart for the expansion of quantum fields as sum of modes in terms of topological field quanta. Topological field quanta should not lose their identity in the superposition.

2. In the spirit of topological field quantization it would be nice to have topological representation for the superposition and interference without any linearization. To make progress one must return to the roots and ask how the fields are operationally defined. One has test particle and it experiences a gauge force in the field. From the acceleration of the test particle the value of field is deduced. What one observes is the superposition of gauge forces, not of gauge fields.

   (a) Let us just assume that we have two space-time sheets representing field configurations to be effectively superposed. Suppose that they are "on top" of each other with respect to CP_2 degrees of freedom so that their M^4 volumes overlap. The points of the sheets representing the field values that would sum in Maxwell's theory are typically at distance of CP_2 radius of about 10^4 Planck lengths. Wormhole contacts representing the interaction between the field configurations are formed. Hence the analog of linear superposition does not hold true exactly. For instance, amplitude modulation becomes possible. This is however not essential for the argment.

   (b) Test particle could be taken to be fermion which is simultaneously topologically condensed to both sheets. In other words, fermionic CP_2 type almost vacuum extremal touches both sheets and wormhole throats at which the signature of the induced metric changes is formed. Fermion experiences the sum of gauge forces from the two space-time sheets through its wormhole throats. From this one usually concludes that superposition holds true for the induced gauge fields. This assumption is however not true and is also un-necessary in the recent case. In case of topological light rays the representation of modes in given direction in terms of massless extremals makes possible to realize the analogy for the representation of quantum field as sum of modes. The representation does not depend on approximate linearity as in the case of quantum field theories and therefore removes a lot of fuzziness related to the quantum theory. In TGD framework the bosonic action is indeed extremely non-linear (see **Fig. http://tgdtheory.fi/appfigures/fieldsuperpose.jpg** or **Fig. ??** in the appendix of this book).

3. This view about linear superposition has interesting implications. In effective superposition the superposed field patterns do not lose their identity which means that the information about the sources is not lost - this is true at least mathematically. This is nothing but quantum classical correspondence: it is the decomposition of radiation into quanta which allows to conclude that the radiation arrives from a particular astrophysical object. It is also possible to have superposition of fields to zero field in Maxwellian sense but in the sense of TGD both fields patterns still exist. Linear superposition in TGD sense might allow testing using time dependent magnetic fields. In the critical situation in which the magnetic field created by AC current passes through zero, flux quanta have macroscopic size and the direction of the flux quantum changes to opposite.

8.2.2 The Basic Objection Against TGD

The basic objection against TGD is that induced metrics for space-time surfaces in $M^4 \times CP_2$ form an extremely limited set in the space of all space-time metrics appearing in the path integral formulation of General Relativity. Even special metrics like the metric of a rotating black hole fail to be imbeddable as an induced metric. For instance, one can argue that TGD cannot reproduce the post-Newtonian approximation to General Relativity since it involves linear superposition of gravitational fields of massive objects. As a matter fact, Holger B. Nielsen - one of the very few colleagues who has shown interest in my work - made this objection for at least two decades ago

in some conference and I remember vividly the discussion in which I tried to defend TGD with my poor English.

The objection generalizes also to induced gauge fields expressible solely in terms of CP_2 coordinates and their gradients. This argument is not so strong as one might think first since in standard model only classical electromagnetic field plays an important role.

1. Any electromagnetic gauge potential has in principle a local embedding in some region. Preferred extremal property poses strong additional constraints and the linear superposition of massless modes possible in Maxwell's electrodynamics is not possible.

2. There are also global constraints leading to topological quantization playing a central role in the interpretation of TGD and leads to the notions of field body and magnetic body having non-trivial application even in non-perturbative hadron physics. For a very large class of preferred extremals space-time sheets decompose into regions having interpretation as geometric counterparts for massless quanta characterized by local polarization and momentum directions. Therefore it seems that TGD space-time is very quantal. Is it possible to obtain from TGD what we have used to call classical physics at all?

The imbeddability constraint has actually highly desirable implications in cosmology. The enormously tight constraints from imbeddability imply that imbeddable Robertson-Walker cosmologies with infinite duration are sub-critical so that the most pressing problem of General Relativity disappears. Critical and over-critical cosmologies are unique apart from a parameter characterizing their duration and critical cosmology replaces both inflationary cosmology and cosmology characterized by accelerating expansion. In inflationary theories the situation is just the opposite of this: one ends up with fine tuning of inflaton potential in order to obtain recent day cosmology.

Despite these and many other nice implications of the induced field concept and of submanifold gravity the basic question remains. Is the imbeddability condition too strong physically? What about linear superposition of fields which is exact for Maxwell's electrodynamics in vacuum and a good approximation central also in gauge theories. Can one obtain linear superposition in some sense?

1. Linear superposition for small deformations of gauge fields makes sense also in TGD but for space-time sheets the field variables would be the deformations of CP_2 coordinates which are scalar fields. One could use preferred complex coordinates determined about SU(3) rotation to do perturbation theory but the idea about perturbations of metric and gauge fields would be lost. This does not look promising. Could linear superposition for fields be replaced with something more general but physically equivalent?

2. This is indeed possible. The basic observation is utterly simple: what we know is that the *effects* of gauge fields superpose. The assumption that fields superpose is un-necessary! This is a highly non-trivial lesson in what operationalism means for theoreticians tending to take these kind of considerations as mere "philosophy".

3. The hypothesis is that the superposition of the effects of gauge fields occurs when the M^4 projections of space-time sheets carrying gauge and gravitational fields intersect so that the sheets are extremely near to each other and can touch each other (CP_2 size is the relevant scale). Particles having topological sum contacts to these space-time sheets experience the sum of the gauge and gravitational fields associated with the space-time sheets.

A more detailed formulation goes as follows.

1. One can introduce common M^4 coordinates for the space-time sheets. A test particle (or real particle) is identifiable as a wormhole contact and is therefore point-like in excellent approximation. In the intersection region for M^4 projections of space-time sheets the particle forms topological sum contacts with all the space-time sheets for which M^4 projections intersect.

2. The test particle experiences the sum of various gauge potentials of space-time sheets involved. For Maxwellian gauge fields linear superposition is obtained. For non-Abelian gauge fields gauge fields contain interaction terms between gauge potentials associated with different space-time sheets. Also the quantum generalization is obvious. The sum of the fields induces quantum transitions for states of individual space time sheets in some sense stationary in their internal gauge potentials.

3. The linear superposition applies also in the case of gravitation. The induced metric for each space-time sheet can be expressed as a sum of Minkowski metric and CP_2 part having interpretation as gravitational field. The natural hypothesis that in the above kind of situation the effective metric is sum of Minkowski metric with the sum of the CP_2 contributions from various sheets. The effective metric for the system is well-defined and one can calculate a curvature tensor for it among other things and it contains naturally the interaction terms between different space-time sheets. At the Newtonian limit one obtains linear superposition of gravitational potentials. One can also postulate that test particles move along geodesics in the effective metric. These geodesics are not geodesics in the induced metrics of the individual space-time sheets.

4. This picture makes it possible to interpret classical physics as the physics based on effective gauge and gravitational fields and applying in the regions where there are very many space-time sheets for which M^4 projections intersect. The loss of quantum coherence would be due to the effective superposition of very many modes having random phases.

The effective superposition of the CP_2 parts of the induced metrics gives rise to an effective space-time metric, which is not in general imbeddable to $M^4 \times CP_2$. Therefore many-sheeted space-time (see **Fig.** `http://tgdtheory.fi/appfigures/manysheeted.jpg` or **Fig.** 9 in the appendix of this book) makes possible a rather wide repertoire of 4-metrics realized as effective metrics as one might have expected and the basic objection can be circumvented. In asymptotic regions where one can expect single sheetedness, only a rather narrow repertoire of "archetypal" field patterns of gauge fields and gravitational fields defined by topological field quanta is possible. This gives connection with quantum physics and state function reduction.

The skeptic can argue that this still need not make possible the embedding of a rotating black hole metric as induced metric in any physically natural manner. This might be the case but need of course not be a catastrophe. We do not really know whether rotating blackhole metric is realized in Nature. I have indeed proposed that TGD predicts new physics

new physics in rotating systems (see `http://tinyurl.com/yantmeot`) [K118]. Unfortunately, gravity probe B could not check whether this new physics is there since it was located at equator where the new effects vanish.

8.2.3 Induction coils in many-sheeted space-time

I have been trying to concretize many-sheeted space-time by thinking what simple systems involving electric and magnetic fields would look like in many-sheeted space-time. The challenge is highly non-trivial since the basic difference between Maxwell's theory and TGD is that allows extremely limited repertoire of preferred extremals and there is no linear superposition.

1. By general coordinate invariance only 4 field like variables (say CP_2 coordinates) are possible meaning that all classical fields identified as induced fields are expressible in terms of only four field like variables at at given sheet. This has several implications.

The classical field equations determining the space-time surface theory is extremely non-linear although they have simple interpretation as expression for local conservation laws of Poincare charges and color charges. Linear superposition of Maxwell's equations is lost.

Only for so called topological light rays ("massless extremals"), MEs) the linear superposition holds true but in extremely limited sense: for the analogous of plane waves travelling in either direction along ME. One has pulses of arbitrary shape preserving their shape and propagating in single direction only with maximal signal velocity.

2. Strong form of holography (SH) implies that 2-dimensional data at string world sheets and partonic 2-surfaces fix the space-time surfaces. 2-D data include also the tangent spaces of partonic 2-surfaces so that the situation is only effectively 2-D and TGD does not reduce to any kind of string model.

   It is possible that the light-like 3-surfaces defining parton orbits as the boundaries of Minkowskian and Euclidian space-time regions possess dynamical degrees of freedom as conformal equivalence classes. Kac-Moody type transformations trivial at the ends of partonic orbit at boundaries of causal diamond (CD) would generate physically equivalent partonic orbits. There would be n conformal equivalence classes, where n would correspond to the value of Planck constant $h_{eff} = n \times h$. At the ends of orbit all these n sheets of the singular covering would coincide. Possible additional degrees of freedom making partonic 2-surfaces somewhat 3-D would be therefore discrete and make possible dark matter in TGD sense.

   What is clear that single space-time sheet is very simple entity, and one can assign to it only extremely limited set of say solutions of Maxwell's equations. More complex solutions must correspond to many-sheeted space-time surfaces approximated as slightly curved pieces of Minkowski space at the GRT-QFT limit of TGD.

   This limit is discovered by noticing that a test particle touches all sheets of the space-time surface in a given region of Minkowski space - they are extremely near to each other. Test particle experiences sums for the induced gauge potentials and gravitational fields defined is deviations of the induced metric from flat Minkowski metric. These sums corresponds naturally to the gauge potentials and gravitational fields assignable to the GRT-QFT limit. One obtains GRT plus standard model.

   The challenge is to look whether one can indeed construct typical Maxwellian field configurations as sums of electromagnetic gauge potentials represented as induced gauge potentials at various sheets. The simplest configurations would be realizable using only two sheets.

   I have already considered the realization of standing waves not possible as single sheeted structures as $\geq$ 2-sheeted structures carrying the analogs of sinusoidal waves [L40] (see `http://tinyurl.com/q4jyoc5`).

1. The proposal is that magnetic bodies (MBs) use this kind of standing wave patterns to generate biological structures: charged biomolecules would end up the nodal surfaces of the standing wave and become stationary structures. Of course, also time varying nodes are possible.

2. MB could use the MEs parallel to flux tubes connected to a given node of tensor network to generate biological structures at the node. Note that the interference patter would be completely analogous to that of a hologram but allowing more than two waves. As a matter of fact, I considered a vision about living systems as conscious holograms for decades ago [K23] but was not able to invent a concrete model at that time. This Chladni mechanism - as one might call it - could be a general mechanism of morphogenesis and morphostasis.

   Second challenge is provided by the field patterns of an inductance coil with AC current flowing around the boundary of cylinder.

1. The current is typically AC current. Oscillating magnetic field has direction parallel or opposite to the cylinder and electric field field lines rotate around the cylinder. That the geometry of field pattern is this is easy to understand by looking just the general form of the solutions of the Maxwell's equations in question.

2. What is essential is that one has standing wave type field pattern meaning that the fields at all points of the cylinder oscillates in the same phase. The temporal and spatial dependences of the magnetic field separate into product of sinusoidal function and spatial function, which in the simplest situation is constant. One might even regard the standing wave property as a signal of quantum coherence.

   Could one use MEs as building bricks to construct the field pattern associated with the coil?

1. MEs define an extremely general set of (hopefully preferred) extremals of Kähler action. Basic type of ME corresponds to cylindrical regions inside which pulses propagate in the same direction along the cylinder and have transversal polarization. The simplest of them are form $f_{\omega,k}(t,z,u) = sin(\omega t - kz)\epsilon(u)$, where one has $\omega = kc$ and u is an arbitrary function depending on some coordinate of the plane orthogonal to the plane characterized by t and z. For instance, u could be chosen to be the radial coordinate ρ in cylindrical coordinates. The sum of the MEs with fields $f_{\omega,k}$ and $f_{\omega,-k}$ gives rise to an effective standing wave in the axial direction representing just right kind of magnetic and electric fields. The nodal surfaces correspond to the planes $sin(kz) = 0$ and to cylinders $\epsilon(\rho) = 0$ in this case.

2. What is amusing that the field experienced by the test particle would be expressible as sum of the two modes of TGD counterpart of radiation field. If the AC frequency is 50 Hz, the period of radial cylindrical wave characterized by wave vector $k = \omega$ ($c = 1$) is of order wave length $\lambda = 2\pi/k$, which is of order 10^7 meters, order of magnitude of Earth radius! Hence the longitudinal magnetic field is essentially constant for the coils encountered in practical situation. Radial field depends on ρ or some more general transversal coordinate in very general manner.

3. The boundary of the cylinder carries the AC current. The description of this current is a further challenge to TGD and will not be considered here.

One can of course have more general currents generating much more general waves, not necessary standing waves.

1. The general recipe would be simple. These fields can be expressed as a Fourier decomposition of simple sinusoidal field patterns. Assign to each sinusoidal field pattern a space-time sheet in the proposed manner so that superposition for modes is replaced with union of space-time surfaces.

2. The more terms in the Fourier expansion, the larger the number of sheets for the many-sheeted space-time is. The number of space-time sheets gives a measure for the complexity of the system. For instance, a current with form of square pulse is an interesting challenge. Should one approximate the square pulse as a superposition of space-time sheets of its Fourier components?

8.2.4 The Notion Of Conscious Hologram

In TGD inspired theory of consciousness the idea about living system as a conscious hologram (see `http://tinyurl.com/ydx4fuk5`) [K23] is central. It is of course far from clear what this notion means. The notions of interference and superposition of fields are crucial for the description of the ordinary hologram. Therefore the proposed general description for the TGD counterpart for the superposition of fields is a natural starting point for the more precise formulation of the notion of conscious hologram.

1. Consider ordinary hologram first. Reference wave and reflected wave interfere and produce an interference pattern to which the substrate of the hologram reacts so that its absorption coefficient is affected. When the substrate is illuminated with the conjugate of the reference wave, the original reflected wave is generated. The modification of the absorption coefficient is assumed to be proportional to the modulus squared fro the sum of the reflected and reference waves. This implies that the wave reflected from the hologram is in good approximation identical with the original reflected wave.

2. Conscious hologram would be dynamical rather than static. It would be also quantal: the quantum transitions of particles in the fields defined by the hologram would be responsible for the realization of the interference pattern as a conscious experience. The previous considerations actually leave only this option since the interference of classical fields does not happen. Reference wave and reflected wave correspond now to any field configurations. The charged particles having wormhole contacts to the space-time sheets representing the field configurations experience the sum of the fields involved, and this induces quantum jumps

between the quantum states associated with the situation in which only the reference wave is present.

This would induce a conscious experience representing an interference pattern. The reference wave can also correspond to a flux tube of magnetic body carrying a static magnetic field and defining cyclotron states as stationary state. External time dependent magnetic field can replace reflected wave and induces cyclotron transitions. Also radiation fields represented by MEs can represent the reference wave and reflected wave. If there is need for the "reading" of the hologram it would correspond to the addition of a space-time sheet carrying fields which in good approximation have opposite sign and same magnitude as those in the sheet representing reference wave so that the effect on the charged particles reduces to that of the "reflected wave".

This step might be un-necessary since already the formation of hologram would give rise to a conscious experience. On the other hand, the conscious holograms created when the hologram is created and when the conjugate of the reference wave is added give rise to two different conscious representations. This might have something to do with holistic and reductionistic views about the same situation.

3. One can imagine several realizations for the conscious hologram. It seems that the realization at the macroscopic level is essentially four-dimensional. By quantum holography it would reduce at microscopic level to a hologram realized at the 3-D light-like surfaces defining the surfaces at which the signature of induce metric changes (generalized Feynman diagrams having also macroscopic size - anyons (see `http://tinyurl.com/y89xp4bu`) [K84]) or space-like 3-surfaces at the ends of space-time sheets at the two light-like boundaries of CD. Strong form of holography implied by the strong form of general coordinate invariance requires that holograms correspond to collections of partonic 2-surfaces in given measurement resolution. This could be understood in the sense that the charged particles defining the substrate can be described mathematically in terms of the ends of the corresponding light-like 3-surfaces at the ends of CDs. The cyclotron transitions could be thought of as occurring for particles represent as partonic 2-surfaces topologically condensed at several space-time sheets.

One can imagine several applications in TGD inspired quantum biology.

1. One can develop a model for how certain aspects of sensory experience could be understood in terms of interference patterns for signals sent from the biological body to the magnetic body. The information about the relative position of the magnetic body and biological body would be coded by the interference patterns giving rise to conscious sensory percepts. This information would represent

geometric qualia (see `http://tinyurl.com/y7vahkzg`) [K50] giving information about distances and angles basically. There would be a magnetic flux tube representing the analog of the reference wave and magnetic flux tube carrying the analog of reflected wave which could represent the effect of neural activity. When the signal changes with time, cyclotron transitions are induced and conscious percept is generated. In principle it there is no need not compensate for the reference wave although also this is possible.

2. The natural first guess is that EEG rhythms (see `http://tinyurl.com/y9y87z84`) [K44] (and those for its fractal generalization) represent reference waves and that the frequencies in question are either harmonics of cyclotron frequencies or linear combinations of these and Josephson frequency assignable to cell membrane (and possibly its harmonics). The modulation of the membrane resting potential would induce modulations of Josephson frequency and if the modulation is large enough it would generate nerve pulses. These modulations would define the counterpart of the reflected wave. The flux tubes representing unperturbed magnetic field would represent reference waves.

3. For instance, the motion of the biological body relative to the magnetic body changes the signal at the space-time sheets carrying the signal and this generates cyclotron transitions giving rise to a conscious experience. Perhaps the sensation of having a body is based in this mechanism. The signals could emerge directly from cells. It could of course be that this

sensation corresponds to lower level selves rather than us. Second option is that nerve pulses to brain induce the signals sent to the our magnetic body.

4. The motion of biological body relative to the biological body generates virtual sensory experience which could be responsible for the illusions like train illusion and the unpleasant sensory experience about falling down from cliff by just imagining it [K110]. OBEs (see `http://tinyurl.com/y797h78x`) could be also due to the virtual sensory experiences of the magnetic body. One interesting illusion results when one swims long time in windy sea. After the return to the shore one has rather long lasting experience of being still in sea. The explanation is that magnetic body gradually learns to compensate the motion of sea so that the perception of the wavy motion is reduced. At the shore this compensation mechanism however continues to work. This mechanism represents an example of adaptation and could be a very general mechanism. Since also magnetic body uses metabolic energy, this mechanism could have justification in terms of metabolic economy.

   Also thinking as internal, silent speech might be assigned with magnetic body and would represent those aspects of the sensory experience of ordinary speech which involve quantum jumps at magnetic body. This speech would be internal speech since there would be no real sound signal or virtual sound signal from brain to cochlea.

5. Conscious hologram would make possible to represent phase information. This information is especially important for hearing (see `http://tinyurl.com/ybwqawhn`) [K91]. The mere power spectrum is not enough since it is same for speech and its time reversal. Cochlea performs an analysis of sounds to frequencies. It it is not easy to imagine how this process could preserve the phase information associated with the Fourier components. It is believed that both right and left cochlea are needed to abstract the phase difference between the signals arriving to right and left ear allowing to deduce the direction of the source neural mechanisms for this has been proposed but these mechanism are not enough in case of speech. Could there exists a separate holistic representation in which sound wave as a whole generates a single signal interfering with the reference wave at the magnetic body and in this manner represents as a conscious experience the phase?

6. Also the control and reference signals from the magnetic body to biological body could create time dependent interference patterns giving rise to neural response initiating motor actions and other responses. Basically the quantum interference should reduce the magnitude of membrane resting potentials so that nerve pulses would be generated and give rise to motor action. Similar mechanism would be at work at the level of sensory receptors - at least retina. The generation of nerve pulses would mean kind of emergency situation at the neuronal level. Frequency modulation of Josephson radiation would be the normal situation.

8.3 Magnetic Body And Consciousness

In the following some aspects of magnetic body as a basic notion of TGD inspired theory of consciousness is discussed. The discussion emphasizes the difference between Maxwellian and TGD based view about gauge fields in which topological field quantization is in fundamental role. The central question concerns the TGD counterpart for the superposition of classical fields and the answer to this question distinguishes between TGD and Maxwell's electrodynamics and gauge field theories in general. These differences are essential for the vision about living systems as conscious holograms and also for the view about how the Josephson currents determined by cell membrane voltage give rise to representations of the geometry qualia at the magnetic body [K44, K92, K95]. Braiding and reconnection are basic processes changing the topology of the magnetic body and their interpretation in TGD inspired theory of consciousness is discussed briefly.

   One might say that magnetic body is responsible for the third person aspects of consciousness. One could also perhaps say that magnetic body serves as an intentional agent using biological body as a motor instrument and sensory receptor. One must however remember than in TGD inspired theory of consciousness it is in principle wrong to speak about doers of deeds: only quantum jumps- deeds- are real. There is no need to postulate any permanent conscious entity, say "soul". Almost by definition self assimilates with the regions of space-time from which the contents of

consciousness are about and this corresponds to the region of embedding space where the non-determinism of quantum jump is located. Causal diamonds (see `http://tinyurl.com/yblbzk6x`) analogous to Penrose diagrams are the correlates of selves in this sense [K13]. Quantum jump involves a cascade proceeding from the level of CD to the level of sub-CDs identified as correlates of sub-selves interpreted as mental images of self. Negentropy Maximization Principle (see `http://tinyurl.com/yd3mly5m`) implies that the cascade stops when it is not possible to generate negentropy by reducing entropic entanglement [K70].

8.3.1 Questions

It is perhaps best to proceed by making questions. In some other mood I would perhaps use more determined approach and replace questions with assumptions. The basic question is what does one really mean with magnetic body?

1. Is magnetic body a separate entity and connected to biological body with magnetic flux tubes which are like "threads" ? What happens to magnetic body when biological body moves. Does magnetic body move along like a rigid part of body? Or does it remain stationary and the sensation of movement results from the relative motion of magnetic body and biological body. Is magnetic body like observer looking at biological body. Is it responsible for the third person aspect of consciousness?

2. What part of sensory percept and its cognitive representation magnetic body is responsible for? The hypothesis is that sensory organs are seats of the primary qualia and the virtual sensory input from brain allows to build standardized mental sensory mental images. Magnetic body would be responsible for the "geometric" qualia such as distance, angles, positions of objects of perceptive field. The representation at magnetic body would provide the organization of sensory input to percepts consisting of objects. Position of sensory percept would correspond to a position at magnetic body: for instance the pattern associated with a sensation of touch (it is possible to "see" through tactile sense). The interference with connections to magnetic body and affecting signals sent to magnetic body should affect these aspects of sensory perception and cognition.

   Magnetic body can be regarded as a virtual body. For instance, OBEs (see `http://tinyurl.com/y797h78x`) could be understood in terms of magnetic body. Moving train illusion is an everyday example about OBE [K110]. Personal magnetic body representing also the train starts to move with respect to biological body and in this manner creates the percept about moving train. The unpleasant sensation of falling down from a cliff could is a virtual world effect resulting from the motion of magnetic body relative to biological body. Interference patterns for radiation from biological body to magnetic body. Conscious holograms are responsible for the generation of sensory percepts at the magnetic body and also for the realization of control signals from magnetic body generating nerve pulse patterns give rise to motor actions.

3. What does the connection between body and magnetic body mean? Flux tubes from body -, which can be moving - to the stationary part of the magnetic body? Somewhat like neural pathways from muscles to brain. Biological body is the motor instrument changing its shape and position under the control of magnetic body. Magnetic body uses biological and is relatively stationary in the first approximation. Real motion to the situation in which biological body moves. Of course, also magnetic body can have motor activity and this can be very important for living matter

   "DNA as topological quantum computer" (see `http://tinyurl.com/ybyscdpt`) based on braiding of the flux tubes [K5] and the reconnection processes at the level of biological body accompanying metabolism [K57]). Imagined motion could correspond to a situation in which magnetic body moves.

8.3.2 Magnetic Body And Conscious Holograms

The idea about bio-systems as conscious holograms involves in an essential manner the TGD counterpart for the interference and superposition of classical fields.

1. The TGD based description for interference and superposition of classical fields has been already discussed. Consider two parallel space-time sheets - now magnetic flux tubes. Assume that charged particles having wormhole contacts to both sheets are present and therefore experience effectively the sum of fields associated with the two sheets. Interference pattern is represented as the transition probability as a function of M^4 position. In stationary situation no transitions take place.

2. When the relative position of the biological body and magnetic body change - in particular, when the distance between magnetic body and biological body is changed - the interference pattern changes so that either a motion of biological body or magnetic body is experienced as a real motion. This could explain could assign to the sensory percept what could be called geometric qualia such as the position of the sensation represented as a position at magnetic body.

3. The motion of the magnetic body relative to stationary biological body can give rise to virtual world sensory experiences carrying only the geometric qualia. This could give rise to imagination and thinking as internal speech involving all aspects of speech except those assignable to the primary sound quale at cochlea. This would also explain the unpleasant sensation of falling down when one is near cliff.

4. Magnetic body could also move so that the motion of the biological body is compensated so that the metabolic energy used in quantum transitions giving rise to the conscious experience is minimized. Example: swimming a long time swimming in sea creates the experience of being in sea after one has returned to the shore. Magnetic body learns to compensate the motion in sea so that the waves are hardly observed. At the shore this mechanism continues to work and create illusion of being in sea.

5. Correlational opponent processing seems to be a more general concept inspired by this phenomenon. Ron Blue has proposed in his correlational opponent-processing theory (see `http://tinyurl.com/y76w9bz4`) that right and left hemisphere form opponents for each other creating opposite reactions. The above argument suggests that magnetic body and biological body could form this kind of pair. Magnetic body would tend to generate compensating effect cancelling the effect caused by motion of biological body with respect to magnetic body to minimize metabolism. This would in general lead to a habituation.

6. Opponent process-theory (see `http://tinyurl.com/348fwq`) is a psychological and neurological model inspired by the observation that emotional response is often followed by its opposite. Could also this phenomenon relate somehow to the relationship between biological and magnetic body? This does not look plausible. Maybe generalized second law of thermodynamics (see `http://tinyurl.com/ybg8qypx`) [L8] - stating that although the generation of genuine negentropy is possible locally it is always compensated by a generation of entropy somewhere else - could provide more natural explanation for this.

8.3.3 Topological Effects On Magnetic Flux Quanta Affecting The Biological Body-Magnetic Body Connection

Magnetic flux tubes make possible braiding and reconnection of flux tubes. These processes are fundamental in TGD inspired quantum biology. Braiding and reconnection are also possible for magnetic field lines and therefore in Maxwellian electrodynamics.

1. Braiding of flux tubes makes possible topological quantum computation like processes. This leads to the idea about DNA as topological quantum computer (see `http://tinyurl.com/ybyscdpt`) [K5]. p-Adic fractality implies that there are flux tubes inside flux tubes defining braids with braids. Also the connections between biological body and magnetic body could define braids and make possible quantum computation like processes. Could it be possible to affect braiding artificially and affect cognition?

2. Reconnection of flux tubes is second topological process. Reconnection process for flux tubes changes the topology of the magnetic field. For instance, magnetic storms and auroras

involve reconnection process occurring in astrophysical scale. Currents flowing along flux tubes are redistributed in the process. The proposal is that flux tubes serve as correlates of attention [K5]. In living matter at cellular level the reconnections of flux tubes connecting flux tubes would be occurring all the time. The process transforming ATP to ADP and vice versa could be seen as a reconnection at molecular level.

Could reconnection between flux tubes connecting two magnetic bodies A and B - say those assignable to brain hemispheres or two subject persons - leading to a splitting of the connection between the magnetic bodies take place. Could this give rise to a kind of split brain syndrome (see `http://tinyurl.com/s38z2`). Signals from biological body **a** would go to magnetic body B and magnetic body B could induce motor actions at **a**. Does hypnosis involve reconnection? Flux tubes from the subject person (hypnotizer) would not go to her magnetic body but the magnetic body of hypnotizer (subject person)? Hypnotizer uses the magnetic body of the subject person. Is becoming possessed something like this?

3. Two flux tubes leading from biological body to magnetic body could reconnect. To parallel flux tubes- II - would transform to cup and cap. Also the closed flux tubes of the external magnetic field could reconnect with the flux tubes connecting left and right magnetic bodies so that the connection between magnetic bodies is via the magnet which is inanimate matter which entangles entropically. If the magnetic flux tube connections between living systems are correlates for negentropic entanglement, then their splitting or transformation to those between living and inanimate system could mean the transformation of entanglement to entropic entanglement unstable under state function reduction. Could this take place in the experiments of Persinger and lead to a split brain situation and to visitor experiencers?

8.3.4 FM Modulations Of Membrane Potential As Code Of Consciousness?

What AM/FM modulation means using the language of topologically quantized fields? The answer to this question might provide new insights also about whether AM or FM is more natural at quantum level.

1. Does the presence of two space-time sheets whose M^4 projections overlap imply amplitude modulation? Does the modulation of distance between charged plates induce the modulation of voltages which in turn induces modulation of ohmic current which in turn induces modulation of the amplitude of radiation. Note that for Josephson junction - cell membrane is regarded as Josephson junction [K92] - it is *frequency* of Josephson radiation which is modulated.

2. Could frequency modulation reduce to the modulation of magnetic fields or to the modulation of membrane potential inducing the modulation of Josephson frequency?

3. The carrier frequency of speech suffers frequency modulations. Whale song involves frequency modulation. Note that artificially slowed down speech is also strongly frequency modulated.

4. Could it be that at quantum level FM is more natural? Could FM allow to realize some kind of code. In the model of hearing FM for Josephson frequencies of cell membrane induced by amplitude modulation of the membrane potential represent sound frequencies. The representation is based on resonances at the period of sound wave when absorption occurs at cyclotron resonance at the magnetic body.

The cautious conclusion is that FM by periodic or more general temporal pattern induces a variation of membrane potential. This induces a variation of Josephson frequency affecting in turn the input to magnetic body and could generate interesting effects on consciousness and behavior. If the amplitude of the modulation of the membrane potential has too large amplitude, nerve pulse is generated and has mode drastic effect.

8.4   The Relation To Persinger's Work

Anyone - atheist or believer - wanting to learn about Persinger's work and the basic insights of neuro-theology should listen the extremely inspiring talk *God and the Brain - The Persinger "God Helmet", The Brain, and visions of God* (see `http://tinyurl.com/y83pq5vl`) by Todd Murphy [J7]. Persinger's work (for references to the articles by Persinger and collaborators see theWikipedia article about God helmet at `http://tinyurl.com/3cpoyq`) suggests that the temporal pattern of the modulation of magnetic field strength (FM would be in question for slow variations) is important. We do not however know the "code". Also the strength of the magnetic field can be important. Note that the effects of very weak ELF em fields on vertebrate brain (see `http://tinyurl.com/y9y87z84`) take place in amplitude windows [K44].

The modulation of magnetic field would probably induce FM of cyclotron frequencies. The model for hearing (see `http://tinyurl.com/ybwqawhn`) suggests this kind of modulation as a way to represents the frequencies of the sound wave. Also phase information is very important: time reversed speech sounds very different as normal speech but has the same power spectrum. Modulations would be slow in the time scales defined by the audible frequency range..1 seconds would represent lower limit for the variation rate of modulation. Audible frequencies above 20 Hz.

8.4.1   God Helmet

God helmet (see `http://tinyurl.com/3cpoyq`) or Koren helmet named after its inventor is the device used by Persinger and collaborators to study the effects of magnetic field on consciousness. Transcranial magnetic stimulation is not in question: TCMS uses fields of order Tesla whereas Persinger uses magnetic fields with strength of order.01 Gauss. This is 2 per cent of the nominal value of Earth's magnetic field. There is a coil above both temporal lobes and the active coil rotates counterclockwise.

1. At the first stage the coil above right temporal lobe rotates counterclockwise. A chirp sequence is used. Chirp means use of an oscillating magnetic field with maximum amplitude about 1 microTesla with oscillation frequency going gradually down. The interpretation is that right-brain self is activated and dominates conscious experiences. The experiences have negative emotional coloring and sometimes the subject person has even fearful experiences.

2. At second stage both coils rotate counterclockwise. The signal is derived from amygdala and hippocampal EEG. Faraday cage is used to eliminate external electromagnetic perturbations and also sensory deprivation is necessary (subject person is blind-folded and in an acoustic chamber). Earth's magnetic field is present, which might have relevance and is indeed used in experiments related to the hypothesis that the variations in Earth's magnetic field affect consciousness.

   A burst of left brain activity is reported to take place during second stage. Also visitor experience is reported to occur during this period. This can mean meeting of God/light being, of angels, of deceased or of group of "beings", or just sense the presence of some conscious entity. A strong sense of meaning can accompany the experience. 80 per cent of subjec persons experience at least the sense of presence.

8.4.2   Persinger's Experiments And Cyclotron Frequencies?

A more quantitative description of the God helmet experiment assuming that cyclotron frequencies are essential goes as follows.

1. The field strength used by Persinger is of the order.01 Gauss and very weak and different from $B_{end} = .2$ Gauss which is $.4B_E$ with $B_E = .5$ Gauss the nominal value of the Earth's magnetic field. Cyclotron frequencies are by a factor of order $1/20$ smaller than for B_{end}. This gives.75 Hz for Ca^{++}.

   From this it is clear that the changes of cyclotron frequencies would be small in static external field in Persinger's experiments and could be treated as a small perturbation. External magnetic field could superpose with $B_{end} = .2$ Gauss and affect cyclotron states and induce

transitions between them. This would induce effects on EEG visible as frequency modulations. It seems that the period for the oscillation of B must be longer than cyclotron period for this picture to make sense.

2. One expects a fractal hierarchy of field strengths for endogenous magnetic fields and $B \simeq .01$ Gauss could correspond to higher levels of consciousness so that cyclotron frequencies for these fields would be important. In this case the external magnetic field would not be a small perturbation. The cyclotron frequencies of DNA strand carrying charge density of 2 elementary charges per nucleotide from the phosphates depend only weakly on the length of DNA strand and are about 1 Hz in B_{end}. Could the cyclotron radiation from cyclotron states associated with the external magnetic field induce interaction with DNA cyclotron states in field $B_{end} = .2$ Gauss?

3. Consider next the time scales. The stimulation of right brain lasts during the first stage last about half an hour. There are however many lacking bits of data.

   (a) In what range are the values of the rotation frequency for the magnetic field? ELf frequencies are used [J114]. If EEG frequencies are in question the rotation should be slower what the lowest EEG frequency involved and below 1 turn per second.

   (b) The rotated magnetic field is time dependent. Chirp sequences are used to stimulate temporal lobe. What is the duration of single chirp and the frequency range covered during chirp? A good guess is that the frequency range is that of EEG. The natural expectation is that the duration of chirp is much longer than the periods in the frequency range considered. This would mean that one scan entire frequency range and that it makes sense to say that the changes of frequency during chirp is slow as compared to the instantaneous frequency.

   (c) EEG signals from left amygdala or hippocampus are used to stimulate both temporal lobes during the second stage. This means that their natural frequency scale should be in the range 1-100 Hz. These time scales would be shorter than the time scale of order 1 second assignal to Ca^{++}. This suggests that small amplitude modulation of the cyclotron frequencies in EEG range is in question. The signals sent to the magnetic body would be determined by this modulation and at least in the second stage this modification would carry information.

8.4.3 Persinger's Explanation

Persinger's own explanation relies on what might be called neurotheology (see `http://tinyurl.com/bm76c`) [J10].

1. The basic claim of Persinger is that the experiences in question are produced by brain so that meeting of God would not be real. Todd Murphy emphasizes that it is actually impossible to conclude anything about the existence or non-existence of God on basis of these experiments. He however claims that evolution would have developed for brain the ability to produce visions of God which often accompany near death experiences and make it easier to accept the unavoidablity of the biological death. The reader can decide whether these two statements are consistent or not.

2. The general idea is that both right and left amygdala, which are the most sensitive parts of the brain because the membrane potential is nearest to the threshold for nerve pulse generation. The right hippocampus is assumed to be responsible for non-verbal, "silent" thinking and left brain hemisphere to verbal thinking. This general picture is used by Todd Murphy to understand the conscious experiences accompanying death process about which near death experiences give a information. The experiences generated by God helmet during the first stage would be akin to the fearful emotions associated with near death experiences [J116, J9] (NDE). The experiences during the second stage bring in mind the spiritual experiences accompanying death process and having strong positive emotional coloring.

3. Persinger [J114] and Murphy [J7] propose that left amygdala is specialized to produce positive emotions (happiness, bliss, and even experience of encountering God or almost synonymously light being). Right amygdala would be specialized to produce negative emotions (such as fear and horror) and one can assign with it also depressive mood. This is not a generally accepted theory. If one accepts it, the natural question is whether right amygdala could serve as a kind of entropic dump pit and left amygdala as as a highly negentropic structure. The empirical data does not force the poor right amygdala to be a whole-daily sufferer.

Consider now the explanation of the experiences induced by God helmet. The lecture by Todd Murphy (see `http://tinyurl.com/y83pq5vl`) [J7] helps considerably in attempts to understand the gist of the explanation and also helsp to see its problematic aspects.

1. The selves of right and left brain fuse in some sense to form single self normally. The nerve bundles connecting the brain hemispheres allowing communications between them are essential for this integration. Right brain self is assumed to be sub-ordinate for left brain self. Magnetic pulses during the first period decompose self to two pieces: one could call them right and left self.

2. During the first stage the mental images from the right brain self become dominating and fearful experiences are due to the fact that right brain amygdala, which is specialized to produce negative emotions, is hyper-active. This phase is believed to break the connection between left and right brain hemispheres. The anecdotal evidence by Todd Murphy suggests a correlation between non-verbal mood of consciousness and negative emotions. One must be however very cautious because extreme fear and horror alone might make impossible not only verbal communication but any coherent action.

3. During the second stage both left and right brain are stimulated and expected contribute to the mental images of self when the connection between the hemispheres is intact. If I have understood correctly, the proposal is that the splitting of self to separate selves induced during the first phase is present almost permanently during the second phase and that left brain self dominates.

4. The temporary "intrusion" of the right hemisphere self to the consciousness of left brain self would give rise to visitor experience. Intrusions would mean occasional re-establishment of the connection between hemispheres. One can question the assumption that God experience and the sensed presence represent instances of the same basic experience due to the intrusion. One could also argue that sensed presence is a signal for the breakdown of the connection and is created by the realization that there is also another self using the same biological body.

5. The model of Todd Murphy for near death experiences would be that right amygdala can give rise to extremely frightening experiences but that the flow of the information to left amygdala transforms this experience to its emotional opposite. The right hippocampus suggested to be responsible for "silent" thinking would be responsible to the experiences of deep meaningfulness and of understanding. To my opinion this picture is too complex and involves too many ad hoc assumptions.

Somehow my personal feeling is that this model is not quite correct. For instance, I do not understand the meaning "intrusion" ? This could be of course be just my misunderstanding. Also the hypothesis about the specialization of left and right amygdala looks strange.

8.4.4   The TGD Based Interpretation Of The God Helmet Experiments

To my opinion also other interpretations for the findings of Persinger can be imagined.

Frequency modulation as a "code of consciousness"

Maxwell's electrodynamics would suggest that a superposition of endogenous and external magnetic fields takes place in God helmet experiments and is partially responsible for the effects. This is clear from the fact that quite specific magnetic stimulation is used (signals derived from EEG during the second stage). In TGD framework one should be able to interpret this.

1. In TGD Universe endogenous magnetic fields could form a fractal hierarchy: flux quanta inside flux quanta. Several critical values of magnetic field expected. Flux quanta could be flux tubes or sheets (DNA strands could be traversed by flux sheets and one could have hierarchy of genomes making possible collective gene expression at various levels).

2. There is a hierarchy of Planck constants so that one can assign to the cell membrane potential a Josephson frequency proportional to $1/\hbar$ and to cyclotron frequencies photon energy proportional to $\hbar$ [K44].

3. The code for the communications from biological body to various levels of the magnetic body relies on the modulation of the Josephson frequencies assignable to the cell membrane. Assuming that the value of Planck constant is integer multiple of its standard value these frequencies span an enormous range. In the case of EEG the Planck constant is of order 10^{13} in order to for photons with the energy of visible photon to have frequency about 10 Hz. Since Josephson frequency is proportional to the membrane potential, the modulations of the membrane potential induce modulations of Josephson frequency so that the signal sent to the magnetic body is modulated and this frequency modulation must define the "code of consciousness".

4. The frequencies involved with these communications are sums of harmonics of Josephson frequency and cyclotron frequency and also cyclotron frequencies can be modulated by modulating magnetic fields. The simplest possibility is that the external magnetic field induces modulation of the magnetic field. This modulation is small since the field strength is of order.01 Gauss and by a factor 1/20 smaller than the endogenous magnetic field $B_{end} = .2$ Gauss suggested by the effects of ELF em fields on vertebrate brain. Of course also other field values are expected to be present.

The basic philosophy behind the TGD based model

The basic philosophy behind the TGD based explanation of God helmet experiences differs in many respects from that behind the model of Persinger and Murphy. Therefore it is good to describe this philosophy first.

1. In the normal social consciousness based strongly on verbal communications the left brain self dominates and social interactions actually split the left brain self from right brain self so that right brain self remains a silent companion unable to express itself except through intuitions. This raises some questions.

   Could just the need to communicate the experience verbally automatically project "me" to left brain me and cut if from "right brain self" so that only the memories of left brain self are communicated. What would happen if the subject person would communicate with external world by singing? Often persons who have lost their ability to speak and comprehend spoken language can communicate by singing. Would the the projection occur to left brain self and could the memories be different?

2. Persinger and Murphy seem to assume that right brain is God from the perspective of the left brain. Magnetic body is responsible for the third person aspect of consciousness and also for the ability to see the dying biological body from the bird's eye perspective during OBEs accompanying also NDEs, which accordingly to Murphy could be quite real. There is indeed evidence that a subject person unable to move from bed has been able to see objects which she should not have been able to see. If magnetic body is real it could also receive extra-sensory information.

   Could the magnetic body of right brain or of the entire brain be in some sense the God from the view point of the brain? The TGD based interpretation (see `http://tinyurl.com/y7qfgcbx`) for the vision of Jaynes about bicameral consviousness as a precedessor of modern consciousness [J90] citeallbsemitrance would conform with this. The God of old testament would be the personal magnetic body which would not have yet become a highly integrated part of self and could be experienced as an outsider. Jaynes also proposes that the consciousness of schizophrenic is much like bicameral consciousness.

3. It is not necessary to assume that the right amygdala is specialized to produce negatively colored motions and left amygdala positive emotions. Same applies also to the proposed roles of right and left hippocampi. In fact, according to Wikipedia article about lateralization of brain function (see `http://tinyurl.com/ye2os3`) depression is linked with hyperactive right hemisphere and selective involvement in "processing negative emotions, pessimistic thoughts and non-constructive thinking styles". A relatively hypoactive left hemisphere is said to be "specifically involved in processing pleasurable experiences" and "relatively more involved in decision-making processes". One can interpret this in many ways. The hyper-activity of right hemisphere could tend to cut its connection with its magnetic body and cause a depressive mood.

   Intense nerve pulse activity could cause this if nerve pulse generation breaks coherence of the EEG oscillation due to the oscillating membrane potentials inducing generation of signals to the magnetic body. The reduced neural activity of left hemisphere would mean a better connection to the magnetic flux tube and positive emotional coloring.

4. Note that this picture conforms with spiritual practices which teach that the manner to achieve piece of mind and bliss is to stop thinking, which indeed means reduce neural activity and more stable connection to the magnetic body. If one takes this conceptualization seriously, one could conclude that the modern hectic society tends to split the connections to the personal magnetic bodies. Since they represent higher levels in the hierarchy of conscious entities, this would lead to a loss of spirituality and also social regression if magnetic bodies are responsible for social structures and cultural evolution.

5. For about 26 years ago I had also a long-lasting "enlightenment" experience - actually two of them. The general structure of these experiences fits with thde proposed general format. The first experience began with the experience of getting in contact with what I spontaneously called Great Mind. I started to make all kinds of questions which I imagined of writing to a monitor that I saw in front of me. Later I realized that the writing was not necessary. I also realized that our communication was severely estricted by the fact that my language did not yet have words for to express the messages of this Great Mind so that the messages contained a lot of "blancos". I had an experience of understanding but did not know what I understand. I also felt that everything around me has extremely deep meaning. One of the first questions I did was "How long I will live?". From the humorous reply expressed as an endless rapid running of a counter containing a long sequence of digits I understood that there is no death. I also asked "Am I alone in this Universe?". The reply was enigmatic "You are a God!". Later it somehow became clear that this God like entity was actually in some sense me. A possible interpretation could be that a new higher layer to the hierarchy of layers of my personal magnetic body had emerged as this God like creature became a part of my personal magnetic body. Much later I realized that this paradoxical realization was the analog for Brahman=Atman identity of Eastern philosophies.

   Consider now the more technical assumptions.

1. One can assume that right and left brain selves can entangle to form a single self and that magnetic flux tubes between brain hemispheres closely associated with the connecting nerve bundles serve as a correlate for this entanglement. In TGD framework the notion of negentropic entanglement (see **Fig. `http://tgdtheory.fi/appfigures/cat.jpg`** or **Fig. ??** in the appendix of this book) makes sense and means entanglement entropy defined number theoretically is negative rather than being positive as usually. Negentropy Maximization Principle for quantum jumps guarantees the stability of negentropic entanglement. Entanglement probabilities must be rational or at most algebraic numbers or negentropic entanglement.

2. The basic mechanism would be reconnection of magnetic flux tubes. Typically two parallel connecting flux tubes would touch each other and reconnect to form U-shaped flux tubes representing flux tubes beginning and returning to left (right magnetic body). What is the role of the external magnetic field in this process? Could the closed flux tubes of the external magnetic fields reconnect with those connecting the right hemisphere to left hemisphere. Suppose that magnetic flux tubes indeed serve as geometric correlates for attention interpreted as negentropic entanglement.

Could one say that the magnet creating chirp signal catches the attention of the right brain magnetic body directed to the right hemisphere? Could the splitting of the connection to the magnetic body create the negative emotions. It is enough that the magnet- magnetic body entanglement becomes entropic to destroy the entanglement in state function reduction if one believes in NMP and perhaps this occurs.

3. One an ask whether this kind of mechanism could explain also the effects of strong (or order 1 Tesla) fields on brain in transcranial magnetic stimulation (see `http://tinyurl.com/s4aw7`) or is the standard explanation in terms of eddy currents inducing nerve pulse patterns enough to explain the effects.

The model for God helmet experiences

Consider now a the general TGD inspired model explaining God helmet experiences.

1. The magnetic chirp during the first stage tends to decouple the right hemisphere from its magnetic body and possibly also from the magnetic body of left brain. This alone creates the negatively colored emotions- kind of feeling of being abandoned by God. This could be also general mechanism of depression and the manner to cure depression would be re-establishment of this connection.

   At quantum level the cutting of the magnetic connection would mean the destruction of entanglement between parts of the two brain hemispheres or between part of right hemisphere and its magnetic body temporarily. This would lead to the splitting of self to right and left brain sub-selves or the loss of the right hemisphere magnetic body entanglement.

2. If one is ready to take seriously the notion of number theoretic entropy [K70], the minimum condition would be that the magnetic chirp causes the entanglement probabilities become non-rational or even non-algebraic numbers so that the number theoretic entropy does not make sense. Ordinary entanglement entropy is always non-negative and state function reduction reduces the entanglement and self splits to two.

3. During the second stage the simultaneous activation of both hemispheres by artificial neuronal signals derived from the EEG of amygdala and hippocampus would fuse both hemispheres to single coherent unit so that the mental images of the right hemisphere would contribute to the conscious experience. The coherence could increase from what it is during ordinary wake-up consciousness dominated by verbal communications. "Being nearer to God" alone could give rise to highly positively colored emotions and to a direct experience of seeing the God/light being/magnetic body and explain the experience of meaningfulness and deep understanding without being able to express what one understands. This inability could be simply to the lack of appropriate language. There is no need to assign this experience to the right hippocampus.

Part III

DARK MATTER AND QUANTUM BIOLOGY

Chapter 9

Dark Forces and Living Matter

9.1 Introduction

The unavoidable presence of classical long ranged weak (and also color) gauge fields in TGD Universe has been a continual source of worries for more than two decades. The basic question has been whether electro-weak charges of elementary particles are screened in electro-weak length scale or not. The TGD based view about dark matter assumes that weak charges are indeed screened for ordinary matter in electro-weak length scale but that dark electro-weak bosons correspond to much longer symmetry breaking length scale.

The large value of $\hbar$ in dark matter phase implies that Compton lengths and -times are scaled up. In particular, the sizes of nucleons and nuclei become of order atom size so that dark nuclear physics would have direct relevance for condensed matter physics. It becomes impossible to make a reductionistic separation between nuclear physics and condensed matter physics and chemistry anymore. This view forces a profound re-consideration of the earlier ideas in nuclear and condensed physics context. It however seems that most of the earlier ideas related to the classical Z^0 force and inspired by anomaly considerations survive in a modified form.

The weak form of electric-magnetic duality led to the identification of the long sought for mechanism causing the weak screening in electroweak scales. The basic implication of the duality is that Kähler electric charges of wormhole throats representing particles are proportional to Kähler magnetic charges so that the CP_2 projections of the wormhole throats are homologically non-trivial. The Kähler magnetic charges do not create long range monopole fields if they are neutralized by wormhole throats carrying opposite monopole charges and weak isospin neutralizing the axial isospin of the particle's wormhole throat. One could speak of confinement of weak isospin. The weak field bodies of elementary fermions would be replaced with string like objects with a length of order W boson Compton length. Electro-magnetic flux would be feeded to electromagnetic field body where it would be feeded to larger space-time sheets. Similar mechanism could apply in the case of color quantum numbers. Weak charges would be therefore screened for ordinary matter in electro-weak length scale but dark electro-weak bosons correspond to much longer symmetry breaking length scale for weak field body. Large values of Planck constant would make it possible to zoop up elementary particles and study their internal structure without any need for gigantic accelerators.

One can still worry about large parity breaking effects - say in nuclear physics- since the couplings of spinors to classical weak fields are there. Around 2012 it became clear that the condition that induced spinor fields have well defined em charge localizes their modes in the generic case to 2-surfaces carrying vanishing induced W gauge fields. It is quite possible that this localization is consistent with Kähler-Dirac equation only in ther Minkowskian regions were the effective metric defined by Kähler-Dirac gamma matrices can be effectively 2-dimensional.

On can pose the additional condition that also classical Z^0 field vanishes - at least above weak scale. Fundamental fermions would experience only em field so that the worries related to large parity breaking effects would disappear. The proportionality of weak scale to $h_{eff} = n \times h$ however predicts that weak fields are effectively massless belong scaled up weak scale. Therefore worries about large parity breaking effects in ordinary nuclear physics can be forgotten.

In its original form this chapter was an attempt to concretize and develop ideas related to dark matter by using some experimental inputs with emphasis on the predicted interaction between the new nuclear physics and condensed matter. As the vision about dark matter became more coherent and the nuclear string model developed in its recent form, it became necessary to update the chapter and throw away the obsolete material. I dare hope that the recent representation is more focused than the earlier one.

9.1.1 Evidence For Long Range Weak Forces And New Nuclear Physics

There is a lot of experimental evidence for long range electro-weak forces, dark matter, and exotic nuclear physics giving valuable guidelines in the attempts to build a coherent theoretical scenario.

Cold fusion

Cold fusion [C3] is a phenomenon involving new nuclear physics and the known selection rules give strong constraints when one tries to understand the character of dark nuclear matter. The simplest model for cold fusion found hitherto is based on the nuclear string model [L3]. [L3] and will be taken as the basis of the considerations of this chapter. Also comparisons with the earlier variant of model of cold fusion [K108] will be made in the section about cold fusion.

Large parity breaking effects

Large parity breaking effects in living matter indicate the presence of long ranged weak forces, and the reported nuclear transmutations in living matter [C1, C12] suggest that new nuclear physics plays a role also now. For instance, the Gaussian Mersennes $(1+i)^k - 1$ for $k = 113, 151, 157163, 167$ could correspond to weak length scales and four biologically important length scales in the range 10 nm-25 μm, which seem to relate directly to the coiling hierarchy of DNA double strands.

Anomalies of the physics of water

The physics of water involves a large number of anomalies and life depends in an essential way on them. As many as 41 anomalies are discussed in the excellent web page "Water Structure and Behavior" of M. Chaplin [D58]. The fact that the physics of heavy water differs much more from that of ordinary water as one might expect on basis of different masses of water molecules suggests that dark nuclear physics is involved.

1. The finding that one hydrogen atom per two water molecules remain effectively invisible in neutron and electron interactions in atto-second time scale [D58, D55] suggests that water is partially dark. These findings have been questioned in [D68] and thought to be erroneous in [D36]. If the findings are real, dark matter phase made of super-nuclei consisting of protons connected by dark color bonds could explain them as perhaps also the clustering of water molecules predicting magic numbers of water molecules in clusters. If so, dark nuclear physics could be an essential part of condensed matter physics and biochemistry. For instance, the condensate of dark protons might be essential for understanding the properties of bio-molecules and even the physical origin of van der Waals radius of atom in van der Waals equation of state.

2. The observation that the binding energy of dark color bond for $n = 2^{11} = 1/v_0$ of the scaling of $\hbar$ corresponds to the bond energy.5 eV of hydrogen bond raises the fascinating possibility that hydrogen bonds is accompanied by a color bond between proton and oxygen nucleus. Also more general chemical bonds might be accompanied by color bonds so that dark color physics might be an essential part of molecular physics. Color bonds might be also responsible for the formation of liquid phase and thus solid state. Dark weak bonds between nuclei could be involved and might be responsible for the repulsive core of van der Waals force and be part of molecular physics too. There is evidence for two kinds of hydrogen bonds [D56] : a possible identification is in terms of p-adic scaling of hydrogen bonds by a factor 2. This kind of doubling is predicted by nuclear string model [L3], [L3].

3. Years after writing this piece of text emerged the idea that covalent bonds of biopolymers might be accompanied by color bonds carrying the metabolic energy liberated in the decay of these polymers [K58]. Polymer like sequences of "half-dark" water molecules with one dark proton with dark protons connected by color bonds to form dark nucleus could have emerged as prebiotic counterparts of biomolecules and carry metabolic energy in color bonds and realize genetic code [K53, L3]. They could accompany ordinary bio-bolymers in water environment and color bonds could carry the metabolic energy. There are of course many other options, and one must have open mind since the belief that biochemistry is understood reduces to high extent to the belief in the reductionistic dogma.

4. Tetrahedral water clusters consisting of 14 water molecules would contain 8 dark protons which corresponds to a magic number for a dark nucleus consisting of protons. Icosahedral water clusters in turn consist of 20 tetrahedral clusters. This raises the question whether fractally scaled up super-nuclei could be in question. If one accepts the vision about dark matter hierarchy based in Jones inclusions to be discussed briefly later, tetrahedral and icosahedral structures of water could correspond directly to the unique genuinely 3-dimensional $G_a = E_6$ and E_8 coverings of CP_2 with $n_a = 3$ and $n_a = 5$ assignable to dark electrons. Icosahedral structures are also very abundant in living matter, mention only viruses.

Other anomalies

There are also other anomalies which might relate to the hierarchy of Planck constants and also to dark weak forces.

1. Exotic chemistries

Exotic chemistries [D65] in which clusters of atoms of given given type mimic the chemistry of another element. These systems behave as if nuclei would form a jellium (constant charge density) defining a harmonic oscillator potential for electrons. Magic numbers correspond to full electron shells analogous to noble gas elements. It is difficult to understand why the constant charge density approximation works so well. If nuclear protons are in large $\hbar(M^4)$ phase with Fermat integer $n_F = 3 \times 2^{11}$, the electromagnetic sizes of nuclei would be about 2.4 Angstroms and the approximation would be natural.

As a matter, fact nuclear string model predicts that the nuclei can have as many as $3A$ exotic charge states obtained by giving neutral color bond charge ± 1: this would give rise to quite different kind of alchemy [L3]. [L3] revealing itself in cold fusion.

2. Free energy anomalies

The anomalies reported by free energy researchers such as over unity energy production in devices involving repeated formation and dissociation of H_2 molecules based on the original discovery of Nobelist Irwing Langmuir [D47] (see for instance [H6]) suggest that part of H atoms might end up to dark matter phase liberating additional energy. The "mono-atomic" elements of Hudson suggest also dark nuclear physics [H3]. There is even evidence for macroscopic transitions to dark phase [H11, H7, H5].

3. Tritium beta decay anomaly and findings of Shnoll

Tritium beta decay anomaly [C5, C7, C10, C8] suggests exotic nuclear physics related to weak interactions. The evidence for the variation of the rates of nuclear and chemical processes correlating with astrophysical periods [E6] , [E6] could be understood in terms of weak fields created by dark matter and affect by astrophysical phenomena.

9.1.2 Dark Rules

I have done a considerable amount of trials and errors in order to identify the basic rules allowing to understand what it means to be dark matter is and what happens in the phase transition to dark matter. It is good to try to summarize the basic rules of p-adic and dark physics allowing to avoid obvious contradictions.

The notion of field body

The notion of "field body" implied by topological field quantization is essential. There would be em, $Z0$, W, gluonic, and gravitonic field bodies, each characterized by its one prime. The motivation for considering the possibility of separate field bodies seriously is that the notion of induced gauge field means that all induced gauge fields are expressible in terms of four CP_2 coordinates so that only single component of a gauge potential allows a representation as and independent field quantity. Perhaps also separate magnetic and electric field bodies for each interaction and identifiable as flux quanta must be considered. This kind of separation requires that the fermionic content of the flux quantum (say fermion and anti-fermion at the ends of color flux tube) is such that it conforms with the quantum numbers of the corresponding boson.

What is interesting that the conceptual separation of interactions to various types would have a direct correlate at the level of space-time topology. From a different perspective inspired by the general vision that many-sheeted space-time provides symbolic representations of quantum physics, the very fact that we make this conceptual separation of fundamental interactions could reflect the topological separation at space-time level.

The p-adic mass calculations for quarks encourage to think that the p-adic length scale characterizing the mass of particle is associated with its electromagnetic body and in the case of neutrinos with its Z^0 field body. Z^0 field body can contribute also to the mass of charged particles but the contribution would be small. It is also possible that these field bodies are purely magnetic for color and weak interactions. Color flux tubes would have exotic fermion and anti-fermion at their ends and define colored variants of pions. This would apply not only in the case of nuclear strings but also to molecules and larger structures so that scaled variants of elementary particles and standard model would appear in all length scales as indeed implied by the fact that classical electro-weak and color fields are unavoidable in TGD framework.

One can also go further and distinguish between magnetic field body of free particle for which flux quanta start and return to the particle and "relative field" bodies associated with pairs of particles. Very complex structures emerge and should be essential for the understanding the space-time correlates of various interactions. In a well-defined sense they would define space-time correlate for the conceptual analysis of the interactions into separate parts. In order to minimize confusion it should be emphasized that the notion of field body used in this chapter relates to those space-time correlates of interactions, which are more or less *static* and related to the formation of *bound states*.

What dark variant of elementary particle means

It is not at all clear what the notion of dark variant of elementary particle or of larger structures could mean.

1. Are only field bodies dark?

One variety of dark particle is obtained by making some of the field bodies dark by increasing the value of Planck constant. This hypothesis could be replaced with the stronger assumption that elementary particles are maximally quantum critical systems so that they are same irrespective of the value of the Planck constant. Elementary particles would be represented by partonic 2-surfaces, which belong to the universal orbifold singularities remaining invariant by all groups $G_a \times G_b$ for a given choice of quantization axes. If $G_a \times G_b$ is assumed to leave invariant the choice of the quantization axes, it must be of the form $Z_{n_a} \times Z_{n_b} \subset SO(3) \times SU(3)$. Partonic 2-surface would belong to $M^2 \times CP_2/U(1) \times U(1)$, where M^2 is spanned by the quantization axis of angular momentum and the time axis defining the rest system.

A different way to say this is that the CP_2 type extremal representing particle would suffer multiple topological condensation on its field bodies so that there would be no separate "particle space-time sheet".

Darkness would be restricted to particle interactions if it is assigned with topological field quanta mediating interactions. The value of the Planck constant would be assigned to a particular interaction between systems rather than system itself. This conforms with the original finding that gravitational Planck constant satisfies $\hbar_{gr} = GM_1M_2/v_0$, $v_0 \simeq 2^{-11}$. Since each interaction can give rise to a hierarchy dark phases, a rich variety of partially dark phases is predicted. The

standard assumption that dark matter is visible only via gravitational interactions would mean that gravitational field body would not be dark for this particular dark matter. Note however that gravitational Planck constant h_{fr} having gigantic values could have different origin as Planck constant h_{eff} emerging from considerations related to biology: this is discussed in [K104].

Complex combinations of dark field bodies become possible and the dream is that one could understand various phases of matter in terms of these combinations. All phase transitions, including the familiar liquid-gas and solid-liquid phase transitions, could have a unified description in terms of dark phase transition for an appropriate field body. At mathematical level Jones inclusions would provide this description.

The book metaphor for the interactions at space-time level is very useful in this framework. Elementary particles correspond to ordinary value of Planck constant analogous to the ordinary sheets of a book and the field bodies mediating their interactions are the same space-time sheet or at dark sheets of the book.

2. Can also elementary particles be dark?

Also dark elementary particles themselves rather than only the flux quanta could correspond to dark space-time sheet defining multiple coverings of $H/G_a \times G_b$. This would mean giving up the maximal quantum criticality hypothesis in the case of elementary particles. These sheets would be exact copies of each other. If single sheet of the covering contains topologically condensed space-time sheet, also other sheets contain its exact copy.

The question is whether these copies of space-time sheet defining classical identical systems can carry different fermionic quantum numbers or only identical fermionic quantum numbers so that the dark particle would be exotic many-fermion system allowing an apparent violation of statistics (N fermions in the same state).

Even if one allows varying number of fermions in the same state with respect to a basic copy of sheet, one ends up with the notion of N-atom in which nuclei would be ordinary but electrons would reside at the sheets of the covering. The question is whether symbolic representations essential for understanding of living matter could emerge already at molecular level via the formation of N-atoms.

Criterion for the transition to dark phase

The criterion $\alpha Q_1 Q_2 > 1$ for the transition to dark matter phase relates always to the interaction between two systems and the interpretation is that when the field strength characterizing the interaction becomes too strong, the interaction is mediated by dark space-time sheets which define $n = n(G_a) \times n(G_b)$-fold covering of $M^4 \times CP_2/G_a \times G_b$. The sharing of flux between different space-time sheets reduces the field strength associated with single sheet below the critical value.

Mersenne hypothesis

The generalization of the embedding space means a book like structure for which the pages are products of singular coverings or factor spaces of CD (causal diamond defined as intersection of future and past directed light-cones) and of CP_2 [K46]. This predicts that Planck constants are rationals and that given value of Planck constant corresponds to an infinite number of different pages of the Big Book, which might be seen as a drawback. If only singular covering spaces are allowed the values of Planck constant are products of integers and given value of Planck constant corresponds to a finite number of pages given by the number of decompositions of the integer to two different integers.

TGD inspired quantum biology and number theoretical considerations suggest preferred values for $r = \hbar/\hbar_0$. For the most general option the values of $\hbar$ are products and ratios of two integers n_a and n_b. Ruler and compass integers defined by the products of distinct Fermat primes and power of two are number theoretically favored values for these integers because the phases $exp(i2\pi/n_i)$, $i \in \{a, b\}$, in this case are number theoretically very simple and should have emerged first in the number theoretical evolution via algebraic extensions of p-adics and of rationals. p-Adic length scale hypothesis favors powers of two as values of r.

One can however ask whether a more precise characterization of preferred Mersennes could exist and whether there could exists a stronger correlation between hierarchies of p-adic length

scales and Planck constants. Mersenne primes $M_k = 2^k - 1$, $k \in \{89, 107, 127\}$, and Gaussian Mersennes $M_{G,k} = (1+i)k - 1$, $k \in \{113, 151, 157, 163, 167, 239, 241..\}$ are expected to be physically highly interesting and up to $k = 127$ indeed correspond to elementary particles. The number theoretical miracle is that all the four scaled up electron Compton lengths with $k \in \{151, 157, 163, 167\}$ are in the biologically highly interesting range 10 nm-2.5 μm). The question has been whether these define scaled up copies of electro-weak and QCD type physics with ordinary value of $\hbar$. The proposal that this is the case and that these physics are in a well-defined sense induced by the dark scaled up variants of corresponding lower level physics leads to a prediction for the preferred values of $r = 2^{k_d}$, $k_d = k_i - k_j$.

What induction means is that dark variant of exotic nuclear physics induces exotic physics with ordinary value of Planck constant in the new scale in a resonant manner: dark gauge bosons transform to their ordinary variants with the same Compton length. This transformation is natural since in length scales below the Compton length the gauge bosons behave as massless and free particles. As a consequence, lighter variants of weak bosons emerge and QCD confinement scale becomes longer.

This proposal will be referred to as Mersenne hypothesis. It leads to strong predictions about EEG [K44] since it predicts a spectrum of preferred Josephson frequencies for a given value of membrane potential and also assigns to a given value of $\hbar$ a fixed size scale having interpretation as the size scale of the body part or magnetic body. Also a vision about evolution of life emerges. Mersenne hypothesis is especially interesting as far as new physics in condensed matter length scales is considered: this includes exotic scaled up variants of the ordinary nuclear physics and their dark variants. Even dark nucleons are possible and this gives justification for the model of dark nucleons predicting the counterparts of DNA, RNA, tRNA, and amino-acids as well as realization of vertebrate genetic code [K119].

These exotic nuclear physics with ordinary value of Planck constant could correspond to ground states that are almost vacuum extremals corresponding to homologically trivial geodesic sphere of CP_2 near criticality to a phase transition changing Planck constant. Ordinary nuclear physics would correspond to homologically non-trivial geodesic sphere and far from vacuum extremal property. For vacuum extremals of this kind classical Z^0 field proportional to electromagnetic field is present and this modifies dramatically the view about cell membrane as Josephson junction. The model for cell membrane as almost vacuum extremal indeed led to a quantitative breakthrough in TGD inspired model of EEG and is therefore something to be taken seriously. The safest option concerning empirical facts is that the copies of electro-weak and color physics with ordinary value of Planck constant are possible only for almost vacuum extremals - that is at criticality against phase transition changing Planck constant.

9.1.3 Weak Form Of Electric Magnetic Duality, Screening Of Weak Charges, And Color Confinement?

TGD predicts the presence of long range classical weak fields and color fields and one should understand classically why quarks and leptons do not couple to these fields above weak boson length scale. Why the quarks inside ordinary nuclei do not generate long range weak fields and do not couple to them? Obviously the weak charges of quarks must be screened so that only electromagnetic charge remains. The extreme non-linearity of field equations in principle allows non-vanishing vacuum charge densities making possible this kind of screening. I have not been able to develop any detailed model for this.

A rather attractive looking explanation came with the discovery of electric-magnetic duality leading to a considerable progress in the understanding of basic quantum TGD. The basic implication of the duality is that Kähler electric charges of wormhole throats representing particles are proportional to Kähler magnetic charges so that the CP_2 projections of the wormhole throats are homologically non-trivial. The Kähler magnetic charges do not create long range monopole fields if they are neutralized by wormhole throats carrying opposite monopole charges and weak isospin neutralizing the axial isospin of the particle's wormhole throat. One could speak of confinement of weak isospin. The weak field bodies of elementary fermions would be replaced with string like objects with a length of order W boson Compton length. Electro-magnetic flux would be fed to electromagnetic field body where it would be fed to larger space-time sheets. Similar mechanism could apply in the case of color quantum numbers.

One of the basic questions closely related to the weak screening have been whether it is s possible to have a weak analog of the ordinary atom - say neutrino atom. Formally one can of course construct this kind of model and I have indeed doe this. The recent wiew about the screening of weak forces does not however allow neutrino atoms since the weak gauge fluxes flow along flux tubes and are screened by opposite charges at their end rather than being spherically symmetric Coulomb fields. Elementary particles themselves can be regarded as string like objects neutralized above weak boson Compton length. The size of the magnetic flux tubes however scales as $\sqrt{\hbar}$ so that large values of $\hbar$ it is in principle possible to zoom up the elementary particles and see what their interior looks like. This applies to both weak and color forces and might some day make possible study of elementary particles without gigantic accelerators.

9.1.4 Dark Weak Forces And Almost Vacuum Extremals

TGD suggests strongly the presence of long range weak force and the large parity breaking in living matter realized as chiral selection provides support for it. One would however like some more concrete quantitative evidence for the conjecture that the classical weak forces are indeed there. This kind of evidence comes from the model of cell membrane based on the hypothesis that cell membrane correspond to almost vacuum extremal.

1. Induced Kähler form vanishes for vacuum extremals. The condition for vanishing implies that classical Z^0 and electromagnetic fields are proportional to each other so that induced spinor field couples to both these fields. The assumption is that the quarks of nuclei and possibly also neutrinos correspond to a large value of Planck constant and therefore couple to the classical Z^0 field. Atomic electrons would not have these couplings. This modifies dramatically the model for the cell membrane as a Josephson junction and raises the scale of Josephson energies from IR range just above thermal threshold to visible and ultraviolet. The amazing finding is that the Josephson energies for biologically important ions correspond to the energies assigned to the peak frequencies in the biological activity spectrum of photoreceptors in retina suggesting. This suggests that almost vacuum extremals and thus also classical Z^0 fields could be in a central role in the understanding of the functioning of the cell membrane and of sensory qualia. This would also explain the large parity breaking effects in living matter.

   One can construct also a generalization of Josephson junction as transmembrane protein such that Josephson energy is generalized to include also the difference of cyclotron energies over the membrane. This allows to understand the role of protons in metabolism and large value about.5 eV of metabolic energy quantum roughtly 10 times larger that Josephson energy for cell membrane in terms of "square root of thermodynamics" replacing the ordinary thermodynamical model of cell membrane. In this case classical Z^0 force is not necessary. It is of course possible that cell membrane proteins can be in two phases: without or with classical Z^0 fields at string world sheets of dark fermions.

2. A further conjecture is that EEG and its predicted fractally scaled variants which same energies in visible and UV range but different scales of Josephson frequencies correspond to Josephson photons with various values of Planck constant. The decay of dark ELF photons with energies of visible photons would give rise to bunches of ordinary ELF photons. Bio-photons in turn could correspond to ordinary visible photons resulting in the phase transition of these photons to photons with ordinary value of Planck constant. This leads to a very detailed view about the role of dark electromagnetic radiation in biomatter and also to a model for how sensory qualia are realized [K50, K92, K44].

What darkness means in the case of nuclei is that the "weak" field bodies of quarks are dark so that the size scale assignable to them is of order cell size. This does not affect their electromagnetic field bodies so that it is possible to speak about ions in the ordinary sense of the word. If the size scale of a given part of field body corresponds to the Compton length proportional proportional to the p-adic length scale scaled up by $\sqrt{\hbar}$ then cell membrane thickness as a Compton scale for the field body of weak bosons means rather large value of $\hbar \sim 2^{151-89} = 2^{62}\hbar_0$. This would scale down 10^{14} Hz frequency of visible photons to about 10^{-4} Hz.

The appendix of the book gives a summary about basic concepts of TGD with illustrations. Pdf representation of same files serving as a kind of glossary can be found at `http://tgdtheory.fi/tgdglossary.pdf` [L18].

9.2 Weak Form Electric-Magnetic Duality And Its Implications

The notion of electric-magnetic duality [B4] was proposed first by Olive and Montonen and is central in $\mathcal{N} = 4$ supersymmetric gauge theories. It states that magnetic monopoles and ordinary particles are two different phases of theory and that the description in terms of monopoles can be applied at the limit when the running gauge coupling constant becomes very large and perturbation theory fails to converge. The notion of electric-magnetic self-duality is more natural since for CP_2 geometry Kähler form is self-dual and Kähler magnetic monopoles are also Kähler electric monopoles and Kähler coupling strength is by quantum criticality renormalization group invariant rather than running coupling constant. The notion of electric-magnetic (self-)duality emerged already two decades ago in the attempts to formulate the Kähler geometric of world of classical worlds. Quite recently a considerable step of progress took place in the understanding of this notion [K35]. What seems to be essential is that one adopts a weaker form of the self-duality applying at partonic 2-surfaces. What this means will be discussed in the sequel.

Every new idea must be of course taken with a grain of salt but the good sign is that this concept leads to precise predictions. The point is that elementary particles do not generate monopole fields in macroscopic length scales: at least when one considers visible matter. The first question is whether elementary particles could have vanishing magnetic charges: this turns out to be impossible. The next question is how the screening of the magnetic charges could take place and leads to an identification of the physical particles as string like objects identified as pairs magnetic charged wormhole throats connected by magnetic flux tubes.

1. The first implication is a new view about electro-weak massivation reducing it to weak confinement in TGD framework. The second end of the string contains particle having electroweak isospin neutralizing that of elementary fermion and the size scale of the string is electro-weak scale would be in question. Hence the screening of electro-weak force takes place via weak confinement realized in terms of magnetic confinement.

2. This picture generalizes to the case of color confinement. Also quarks correspond to pairs of magnetic monopoles but the charges need not vanish now. Rather, valence quarks would be connected by flux tubes of length of order hadron size such that magnetic charges sum up to zero. For instance, for baryonic valence quarks these charges could be $(2, -1, -1)$ and could be proportional to color hyper charge.

3. The highly non-trivial prediction making more precise the earlier stringy vision is that elementary particles are string like objects: this could become manifest at LHC energies.

4. The weak form electric-magnetic duality together with Beltrami flow property of Kähler leads to the reduction of Kähler action to Chern-Simons action so that TGD reduces to almost topological QFT and that Kähler function is explicitly calculable. This has enormous impact concerning practical calculability of the theory.

5. One ends up also to a general solution ansatz for field equations from the condition that the theory reduces to almost topological QFT. The solution ansatz is inspired by the idea that all isometry currents are proportional to Kähler current which is integrable in the sense that the flow parameter associated with its flow lines defines a global coordinate. The proposed solution ansatz would describe a hydrodynamical flow with the property that isometry charges are conserved along the flow lines (Beltrami flow). A general ansatz satisfying the integrability conditions is found.

   The strongest form of the solution ansatz states that various classical and quantum currents flow along flow lines of the Beltrami flow defined by Kähler current (Kähler magnetic field associated with Chern-Simons action). Intuitively this picture is attractive. A more general

ansatz would allow several Beltrami flows meaning multi-hydrodynamics. The integrability conditions boil down to two scalar functions: the first one satisfies massless d'Alembert equation in the induced metric and the gradients of the scalar functions are orthogonal. The interpretation in terms of momentum and polarization directions is natural.

9.2.1 Could A Weak Form Of Electric-Magnetic Duality Hold True?

Holography means that the initial data at the partonic 2-surfaces should fix the WCW metric. A weak form of this condition allows only the partonic 2-surfaces defined by the wormhole throats at which the signature of the induced metric changes. A stronger condition allows all partonic 2-surfaces in the slicing of space-time sheet to partonic 2-surfaces and string world sheets. Number theoretical vision suggests that hyper-quaternionicity *resp.* co-hyperquaternionicity constraint could be enough to fix the initial values of time derivatives of the embedding space coordinates in the space-time regions with Minkowskian *resp.* Euclidian signature of the induced metric. This is a condition on modified gamma matrices and hyper-quaternionicity states that they span a hyper-quaternionic sub-space.

Definition of the weak form of electric-magnetic duality

One can also consider alternative conditions possibly equivalent with this condition. The argument goes as follows.

1. The expression of the matrix elements of the metric and Kähler form of WCW in terms of the Kähler fluxes weighted by Hamiltonians of $\delta M_{\pm}^4$ at the partonic 2-surface X^2 looks very attractive. These expressions however carry no information about the 4-D tangent space of the partonic 2-surfaces so that the theory would reduce to a genuinely 2-dimensional theory, which cannot hold true. One would like to code to the WCW metric also information about the electric part of the induced Kähler form assignable to the complement of the tangent space of $X^2 \subset X^4$.

2. Electric-magnetic duality of the theory looks a highly attractive symmetry. The trivial manner to get electric magnetic duality at the level of the full theory would be via the identification of the flux Hamiltonians as sums of of the magnetic and electric fluxes. The presence of the induced metric is however troublesome since the presence of the induced metric means that the simple transformation properties of flux Hamiltonians under symplectic transformations -in particular color rotations- are lost.

3. A less trivial formulation of electric-magnetic duality would be as an initial condition which eliminates the induced metric from the electric flux. In the Euclidian version of 4-D YM theory this duality allows to solve field equations exactly in terms of instantons. This approach involves also quaternions. These arguments suggest that the duality in some form might work. The full electric magnetic duality is certainly too strong and implies that space-time surface at the partonic 2-surface corresponds to piece of CP_2 type vacuum extremal and can hold only in the deep interior of the region with Euclidian signature. In the region surrounding wormhole throat at both sides the condition must be replaced with a weaker condition.

4. To formulate a weaker form of the condition let us introduce coordinates (x^0, x^3, x^1, x^2) such (x^1, x^2) define coordinates for the partonic 2-surface and (x^0, x^3) define coordinates labeling partonic 2-surfaces in the slicing of the space-time surface by partonic 2-surfaces and string world sheets making sense in the regions of space-time sheet with Minkowskian signature. The assumption about the slicing allows to preserve general coordinate invariance. The weakest condition is that the generalized Kähler electric fluxes are apart from constant proportional to Kähler magnetic fluxes. This requires the condition

$$J^{03}\sqrt{g_4} \;\; = \;\; K J_{12} \;\; . \tag{9.2.1}$$

A more general form of this duality is suggested by the considerations of [K55] reducing the hierarchy of Planck constants to basic quantum TGD and also reducing Kähler function for preferred extremals to Chern-Simons terms [B2] at the boundaries of CD and at light-like wormhole throats. This form is following

$$J^{n\beta}\sqrt{g_4} \quad = \quad K\epsilon \times \epsilon^{n\beta\gamma\delta}J_{\gamma\delta}\sqrt{g_4} \quad . \tag{9.2.2}$$

Here the index n refers to a normal coordinate for the space-like 3-surface at either boundary of CD or for light-like wormhole throat. ϵ is a sign factor which is opposite for the two ends of CD. It could be also opposite of opposite at the opposite sides of the wormhole throat. Note that the dependence on induced metric disappears at the right hand side and this condition eliminates the potentials singularity due to the reduction of the rank of the induced metric at wormhole throat.

5. Information about the tangent space of the space-time surface can be coded to the WCW metric with loosing the nice transformation properties of the magnetic flux Hamiltonians if Kähler electric fluxes or sum of magnetic flux and electric flux satisfying this condition are used and K is symplectic invariant. Using the sum

$$J_e + J_m \quad = \quad (1+K)J_{12} \quad , \tag{9.2.3}$$

where J denotes the Kähler magnetic flux, , makes it possible to have a non-trivial WCW metric even for $K = 0$, which could correspond to the ends of a cosmic string like solution carrying only Kähler magnetic fields. This condition suggests that it can depend only on Kähler magnetic flux and other symplectic invariants. Whether local symplectic coordinate invariants are possible at all is far from obvious, If the slicing itself is symplectic invariant then K could be a non-constant function of X^2 depending on string world sheet coordinates. The light-like radial coordinate of the light-cone boundary indeed defines a symplectically invariant slicing and this slicing could be shifted along the time axis defined by the tips of CD.

Electric-magnetic duality physically

What could the weak duality condition mean physically? For instance, what constraints are obtained if one assumes that the quantization of electro-weak charges reduces to this condition at classical level?

1. The first thing to notice is that the flux of J over the partonic 2-surface is analogous to magnetic flux

$$Q_m = \frac{e}{\hbar}\oint BdS = n \quad .$$

n is non-vanishing only if the surface is homologically non-trivial and gives the homology charge of the partonic 2-surface.

2. The expressions of classical electromagnetic and Z^0 fields in terms of Kähler form [L2] , [L2] read as

$$\gamma \quad = \quad \frac{eF_{em}}{\hbar} = 3J - sin^2(\theta_W)R_{03} \quad ,$$
$$Z^0 \quad = \quad \frac{g_Z F_Z}{\hbar} = 2R_{03} \quad . \tag{9.2.4}$$

Here R_{03} is one of the components of the curvature tensor in vielbein representation and F_{em} and F_Z correspond to the standard field tensors. From this expression one can deduce

$$J \quad = \quad \frac{e}{3\hbar} F_{em} + sin^2(\theta_W) \frac{g_Z}{6\hbar} F_Z \quad . \tag{9.2.5}$$

3. The weak duality condition when integrated over X^2 implies

$$\frac{e^2}{3\hbar} Q_{em} + \frac{g_Z^2 p}{6} Q_{Z,V} \quad = \quad K \oint J = Kn \quad ,$$
$$Q_{Z,V} \quad = \quad \frac{I_V^3}{2} - Q_{em} \quad , \quad p = sin^2(\theta_W) \quad . \tag{9.2.6}$$

Here the vectorial part of the Z^0 charge rather than as full Z^0 charge $Q_Z = I_L^3 + sin^2(\theta_W) Q_{em}$ appears. The reason is that only the vectorial isospin is same for left and right handed components of fermion which are in general mixed for the massive states.

The coefficients are dimensionless and expressible in terms of the gauge coupling strengths and using $\hbar = r\hbar_0$ one can write

$$\alpha_{em} Q_{em} \quad + \quad p\frac{\alpha_Z}{2} Q_{Z,V} = \frac{3}{4\pi} \times rnK \quad ,$$
$$\alpha_{em} \quad = \quad \frac{e^2}{4\pi\hbar_0} \quad , \quad \alpha_Z = \frac{g_Z^2}{4\pi\hbar_0} = \frac{\alpha_{em}}{p(1-p)} \quad . \tag{9.2.7}$$

4. There is a great temptation to assume that the values of Q_{em} and Q_Z correspond to their quantized values and therefore depend on the quantum state assigned to the partonic 2-surface. The linear coupling of the Kähler-Dirac operator to conserved charges implies correlation between the geometry of space-time sheet and quantum numbers assigned to the partonic 2-surface. The assumption of standard quantized values for Q_{em} and Q_Z would be also seen as the identification of the fine structure constants α_{em} and α_Z. This however requires weak isospin invariance.

The value of K from classical quantization of Kähler electric charge

The value of K can be deduced by requiring classical quantization of Kähler electric charge.

1. The condition that the flux of $F^{03} = (\hbar/g_K)J^{03}$ defining the counterpart of Kähler electric field equals to the Kähler charge g_K would give the condition $K = g_K^2/\hbar$, where g_K is Kähler coupling constant which should invariant under coupling constant evolution by quantum criticality. Within experimental uncertainties one has $\alpha_K = g_K^2/4\pi\hbar_0 = \alpha_{em} \simeq 1/137$, where α_{em} is finite structure constant in electron length scale and $\hbar_0$ is the standard value of Planck constant.

2. The quantization of Planck constants makes the condition highly non-trivial. The most general quantization of r is as rationals but there are good arguments favoring the quantization as integers corresponding to the allowance of only singular coverings of CD andn CP_2. The point is that in this case a given value of Planck constant corresponds to a finite number pages of the "Big Book". The quantization of the Planck constant implies a further quantization of K and would suggest that K scales as $1/r$ unless the spectrum of values of Q_{em} and Q_Z allowed by the quantization condition scales as r. This is quite possible and the interpretation would be that each of the r sheets of the covering carries (possibly same) elementary charge. Kind of discrete variant of a full Fermi sphere would be in question. The interpretation in terms of anyonic phases [K84] supports this interpretation.

3. The identification of J as a counterpart of $eB/\hbar$ means that Kähler action and thus also Kähler function is proportional to $1/\alpha_K$ and therefore to $\hbar$. This implies that for large values of $\hbar$ Kähler coupling strength $g_K^2/4\pi$ becomes very small and large fluctuations are suppressed in the functional integral. The basic motivation for introducing the hierarchy of Planck constants was indeed that the scaling $\alpha \to \alpha/r$ allows to achieve the convergence of perturbation theory: Nature itself would solve the problems of the theoretician. This of course does not mean that the physical states would remain as such and the replacement of single particles with anyonic states in order to satisfy the condition for K would realize this concretely.

4. The condition $K = g_K^2/\hbar$ implies that the Kähler magnetic charge is always accompanied by Kähler electric charge. A more general condition would read as

$$K \quad = \quad n \times \frac{g_K^2}{\hbar}, n \in Z \quad . \tag{9.2.8}$$

This would apply in the case of cosmic strings and would allow vanishing Kähler charge possible when the partonic 2-surface has opposite fermion and anti-fermion numbers (for both leptons and quarks) so that Kähler electric charge should vanish. For instance, for neutrinos the vanishing of electric charge strongly suggests $n = 0$ besides the condition that abelian Z^0 flux contributing to em charge vanishes.

It took a year to realize that this value of K is natural at the Minkowskian side of the wormhole throat. At the Euclidian side much more natural condition is

$$K \quad = \quad \frac{1}{hbar} \quad . \tag{9.2.9}$$

In fact, the self-duality of CP_2 Kähler form favours this boundary condition at the Euclidian side of the wormhole throat. Also the fact that one cannot distinguish between electric and magnetic charges in Euclidian region since all charges are magnetic can be used to argue in favor of this form. The same constraint arises from the condition that the action for CP_2 type vacuum extremal has the value required by the argument leading to a prediction for gravitational constant in terms of the square of CP_2 radius and α_K the effective replacement $g_K^2 \to 1$ would spoil the argument.

The boundary condition $J_E = J_B$ for the electric and magnetic parts of Kählwer form at the Euclidian side of the wormhole throat inspires the question whether all Euclidian regions could be self-dual so that the density of Kähler action would be just the instanton density. Self-duality follows if the deformation of the metric induced by the deformation of the canonically imbedded CP_2 is such that in CP_2 coordinates for the Euclidian region the tensor $(g^{\alpha\beta}g^{\mu\nu} - g^{\alpha\nu}g^{\mu\beta})/\sqrt{g}$ remains invariant. This is certainly the case for CP_2 type vacuum extremals since by the light-likeness of M^4 projection the metric remains invariant. Also conformal scalings of the induced metric would satisfy this condition. Conformal scaling is not consistent with the degeneracy of the 4-metric at the wormhole.

Reduction of the quantization of Kähler electric charge to that of electromagnetic charge

The best manner to learn more is to challenge the form of the weak electric-magnetic duality based on the induced Kähler form.

1. Physically it would seem more sensible to pose the duality on electromagnetic charge rather than Kähler charge. This would replace induced Kähler form with electromagnetic field, which is a linear combination of induced Kahler field and classical Z^0 field

$$\begin{aligned}
\gamma &= 3J - sin^2\theta_W R_{12} \quad , \\
Z^0 &= 2R_{03} \quad .
\end{aligned} \tag{9.2.10}$$

Here $Z_0 = 2R_{03}$ is the appropriate component of CP_2 curvature form [L2]. For a vanishing Weinberg angle the condition reduces to that for Kähler form.

2. For the Euclidian space-time regions having interpretation as lines of generalized Feynman diagrams Weinberg angle should be non-vanishing. In Minkowskian regions Weinberg angle could however vanish. If so, the condition guaranteeing that electromagnetic charge of the partonic 2-surfaces equals to the above condition stating that the em charge assignable to the fermion content of the partonic 2-surfaces reduces to the classical Kähler electric flux at the Minkowskian side of the wormhole throat. One can argue that Weinberg angle must increase smoothly from a vanishing value at both sides of wormhole throat to its value in the deep interior of the Euclidian region.

3. The vanishing of the Weinberg angle in Minkowskian regions conforms with the physical intuition. Above elementary particle length scales one sees only the classical electric field reducing to the induced Kähler form and classical Z^0 fields and color gauge fields are effectively absent. Only in phases with a large value of Planck constant classical Z^0 field and other classical weak fields and color gauge field could make themselves visible. Cell membrane could be one such system [K92]. This conforms with the general picture about color confinement and weak massivation.

The GRT limit of TGD suggests a further reason for why Weinberg angle should vanish in Minkowskian regions.

1. The value of the Kähler coupling strength mut be very near to the value of the fine structure constant in electron length scale and these constants can be assumed to be equal.

2. GRT limit of TGD with space-time surfaces replaced with abstract 4-geometries would naturally correspond to Einstein-Maxwell theory with cosmological constant which is non-vanishing only in Euclidian regions of space-time so that both Reissner-Nordström metric and CP_2 are allowed as simplest possible solutions of field equations [K118]. The extremely small value of the observed cosmological constant needed in GRT type cosmology could be equal to the large cosmological constant associated with CP_2 metric multiplied with the 3-volume fraction of Euclidian regions.

3. Also at GRT limit quantum theory would reduce to almost topological QFT since Einstein-Maxwell action reduces to 3-D term by field equations implying the vanishing of the Maxwell current and of the curvature scalar in Minkowskian regions and curvature scalar + cosmological constant term in Euclidian regions. The weak form of electric-magnetic duality would guarantee also now the preferred extremal property and prevent the reduction to a mere topological QFT.

4. GRT limit would make sense only for a vanishing Weinberg angle in Minkowskian regions. A non-vanishing Weinberg angle would make sense in the deep interior of the Euclidian regions where the approximation as a small deformation of CP_2 makes sense.

The weak form of electric-magnetic duality has surprisingly strong implications for the basic view about quantum TGD as following considerations show.

9.2.2 Magnetic Confinement, The Short Range Of Weak Forces, And Color Confinement

The weak form of electric-magnetic duality has surprisingly strong implications if one combines it with some very general empirical facts such as the non-existence of magnetic monopole fields in macroscopic length scales.

How can one avoid macroscopic magnetic monopole fields?

Monopole fields are experimentally absent in length scales above order weak boson length scale and one should have a mechanism neutralizing the monopole charge. How electroweak interactions

become short ranged in TGD framework is still a poorly understood problem. What suggests itself is the neutralization of the weak isospin above the intermediate gauge boson Compton length by neutral Higgs bosons. Could the two neutralization mechanisms be combined to single one?

1. In the case of fermions and their super partners the opposite magnetic monopole would be a wormhole throat. If the magnetically charged wormhole contact is electromagnetically neutral but has vectorial weak isospin neutralizing the weak vectorial isospin of the fermion only the electromagnetic charge of the fermion is visible on longer length scales. The distance of this wormhole throat from the fermionic one should be of the order weak boson Compton length. An interpretation as a bound state of fermion and a wormhole throat state with the quantum numbers of a neutral Higgs boson would therefore make sense. The neutralizing throat would have quantum numbers of $X_{-1/2} = \nu_L \bar{\nu}_R$ or $X_{1/2} = \bar{\nu}_L \nu_R$. $\nu_L \bar{\nu}_R$ would not be neutral Higgs boson (which should correspond to a wormhole contact) but a super-partner of left-handed neutrino obtained by adding a right handed neutrino. This mechanism would apply separately to the fermionic and anti-fermionic throats of the gauge bosons and corresponding space-time sheets and leave only electromagnetic interaction as a long ranged interaction.

2. One can of course wonder what is the situation situation for the bosonic wormhole throats feeding gauge fluxes between space-time sheets. It would seem that these wormhole throats must always appear as pairs such that for the second member of the pair monopole charges and I_V^3 cancel each other at both space-time sheets involved so that one obtains at both space-time sheets magnetic dipoles of size of weak boson Compton length. The proposed magnetic character of fundamental particles should become visible at TeV energies so that LHC might have surprises in store!

Well-definedness of electromagnetic charge implies stringiness

Well-definedness of electromagnetic charged at string world sheets carrying spinor modes is very natural constraint and not trivially satisfied because classical W boson fields are present. As a matter fact, all weak fields should be effectively absent above weak scale. How this is possible classical weak fields identified as induced gauge fields are certainly present.

The condition that em charge is well defined for spinor modes implies that the space-time region in which spinor mode is non-vanishing has 2-D CP_2 projection such that the induced W boson fields are vanishing. The vanishing of classical Z^0 field can be poses as additional condition - at least in scales above weak scale. In the generic case this requires that the spinor mode is restricted to 2-D surface: string world sheet or possibly also partonic 2-surface. This implies that TGD reduces to string model in fermionic sector. Even for preferred extremals with 2-D projecting the modes are expected to allow restriction to 2-surfaces. This localization is possible only for Kähler-Dirac action.

A word of warning is however in order. The GRT limit or rather limit of TGD as Einstein Yang-Mills theory replaces the sheets of many-sheeted space-time with Minkowski space with effective metric obtained by summing to Minkowski metric the deviations of the induced metrics of space-time sheets from Minkowski metric. For gauge potentials a similar identification applies. YM-Einstein equations coupled with matter and with non-vanishing cosmological constant are expected on basis of Poincare invariance. One cannot exclude the possibility that the sums of weak gauge potentials from different space-time sheet tend to vanish above weak scale and that well-definedness of em charge at classical level follows from the effective absence of classical weak gauge fields.

Magnetic confinement and color confinement

Magnetic confinement generalizes also to the case of color interactions. One can consider also the situation in which the magnetic charges of quarks (more generally, of color excited leptons and quarks) do not vanish and they form color and magnetic singles in the hadronic length scale. This would mean that magnetic charges of the state $q_{\pm 1/2} - X_{\mp 1/2}$ representing the physical quark would not vanish and magnetic confinement would accompany also color confinement. This would

explain why free quarks are not observed. To how degree then quark confinement corresponds to magnetic confinement is an interesting question.

For quark and antiquark of meson the magnetic charges of quark and antiquark would be opposite and meson would correspond to a Kähler magnetic flux so that a stringy view about meson emerges. For valence quarks of baryon the vanishing of the net magnetic charge takes place provided that the magnetic net charges are $(\pm 2, \mp 1, \mp 1)$. This brings in mind the spectrum of color hyper charges coming as $(\pm 2, \mp 1, \mp 1)/3$ and one can indeed ask whether color hypercharge correlates with the Kähler magnetic charge. The geometric picture would be three strings connected to single vertex. Amusingly, the idea that color hypercharge could be proportional to color hyper charge popped up during the first year of TGD when I had not yet discovered CP_2 and believed on $M^4 \times S^2$.

p-Adic length scale hypothesis and hierarchy of Planck constants defining a hierarchy of dark variants of particles suggest the existence of scaled up copies of QCD type physics and weak physics. For p-adically scaled up variants the mass scales would be scaled by a power of $\sqrt{2}$ in the most general case. The dark variants of the particle would have the same mass as the original one. In particular, Mersenne primes $M_k = 2^k - 1$ and Gaussian Mersennes $M_{G,k} = (1+i)^k - 1$ has been proposed to define zoomed copies of these physics. At the level of magnetic confinement this would mean hierarchy of length scales for the magnetic confinement.

One particular proposal is that the Mersenne prime M_{89} should define a scaled up variant of the ordinary hadron physics with mass scaled up roughly by a factor $2^{(107-89)/2} = 512$. The size scale of color confinement for this physics would be same as the weal length scale. It would look more natural that the weak confinement for the quarks of M_{89} physics takes place in some shorter scale and M_{61} is the first Mersenne prime to be considered. The mass scale of M_{61} weak bosons would be by a factor $2^{(89-61)/2} = 2^{14}$ higher and about 1.6×10^4 TeV. M_{89} quarks would have virtually no weak interactions but would possess color interactions with weak confinement length scale reflecting themselves as new kind of jets at collisions above TeV energies.

In the biologically especially important length scale range 10 nm -2500 nm there are as many as four scaled up electron Compton lengths $L_e(k) = \sqrt{5}L(k)$: they are associated with Gaussian Mersennes $M_{G,k}$, $k = 151, 157, 163, 167$. This would suggest that the existence of scaled up scales of magnetic-, weak- and color confinement. An especially interesting possibly testable prediction is the existence of magnetic monopole pairs with the size scale in this range. There are recent claims about experimental evidence for magnetic monopole pairs [D37] .

Magnetic confinement and stringy picture in TGD sense

The connection between magnetic confinement and weak confinement is rather natural if one recalls that electric-magnetic duality in super-symmetric quantum field theories means that the descriptions in terms of particles and monopoles are in some sense dual descriptions. Fermions would be replaced by string like objects defined by the magnetic flux tubes and bosons as pairs of wormhole contacts would correspond to pairs of the flux tubes. Therefore the sharp distinction between gravitons and physical particles would disappear.

The reason why gravitons are necessarily stringy objects formed by a pair of wormhole contacts is that one cannot construct spin two objects using only single fermion states at wormhole throats. Of course, also super partners of these states with higher spin obtained by adding fermions and anti-fermions at the wormhole throat but these do not give rise to graviton like states [**?**] . The upper and lower wormhole throat pairs would be quantum superpositions of fermion anti-fermion pairs with sum over all fermions. The reason is that otherwise one cannot realize graviton emission in terms of joining of the ends of light-like 3-surfaces together. Also now magnetic monopole charges are necessary but now there is no need to assign the entities $X_\pm$ with gravitons.

Graviton string is characterized by some p-adic length scale and one can argue that below this length scale the charges of the fermions become visible. Mersenne hypothesis suggests that some Mersenne prime is in question. One proposal is that gravitonic size scale is given by electronic Mersenne prime M_{127}. It is however difficult to test whether graviton has a structure visible below this length scale.

What happens to the generalized Feynman diagrams is an interesting question. It is not at all clear how closely they relate to ordinary Feynman diagrams. All depends on what one is ready to assume about what happens in the vertices. One could of course hope that zero energy ontology

could allow some very simple description allowing perhaps to get rid of the problematic aspects of Feynman diagrams.

1. Consider first the recent view about generalized Feynman diagrams which relies ZEO. A highly attractive assumption is that the particles appearing at wormhole throats are on mass shell particles. For incoming and outgoing elementary bosons and their super partners they would be positive it resp. negative energy states with parallel on mass shell momenta. For virtual bosons they the wormhole throats would have opposite sign of energy and the sum of on mass shell states would give virtual net momenta. This would make possible twistor description of virtual particles allowing only massless particles (in 4-D sense usually and in 8-D sense in TGD framework). The notion of virtual fermion makes sense only if one assumes in the interaction region a topological condensation creating another wormhole throat having no fermionic quantum numbers.

2. The addition of the particles $X^{\pm}$ replaces generalized Feynman diagrams with the analogs of stringy diagrams with lines replaced by pairs of lines corresponding to fermion and $X_{\pm 1/2}$. The members of these pairs would correspond to 3-D light-like surfaces glued together at the vertices of generalized Feynman diagrams. The analog of 3-vertex would not be splitting of the string to form shorter strings but the replication of the entire string to form two strings with same length or fusion of two strings to single string along all their points rather than along ends to form a longer string. It is not clear whether the duality symmetry of stringy diagrams can hold true for the TGD variants of stringy diagrams.

3. How should one describe the bound state formed by the fermion and $X^{\pm}$? Should one describe the state as superposition of non-parallel on mass shell states so that the composite state would be automatically massive? The description as superposition of on mass shell states does not conform with the idea that bound state formation requires binding energy. In TGD framework the notion of negentropic entanglement has been suggested to make possible the analogs of bound states consisting of on mass shell states so that the binding energy is zero [K70] . If this kind of states are in question the description of virtual states in terms of on mass shell states is not lost. Of course, one cannot exclude the possibility that there is infinite number of this kind of states serving as analogs for the excitations of string like object.

4. What happens to the states formed by fermions and $X_{\pm 1/2}$ in the internal lines of the Feynman diagram? Twistor philosophy suggests that only the higher on mass shell excitations are possible. If this picture is correct, the situation would not change in an essential manner from the earlier one.

The highly non-trivial prediction of the magnetic confinement is that elementary particles should have stringy character in electro-weak length scales and could behaving to become manifest at LHC energies. This adds one further item to the list of non-trivial predictions of TGD about physics at LHC energies [K71] .

9.3 Dark Matter Hierarchy, Genetic Machinery, And The Un-Reasonable Selectivity Of Bio-Catalysis

One of the most fascinating outcomes of ideas related to the dark matter hierarchy is the notion of inherently dark fractional atom (molecule) generalizing the notion of Bose-Einstein condensate to the fermionic case. These notions might provide an elegant manner to understand the mysteries of DNA replication, transcription, and translation, and more generally, the incredible selectivity of bio-catalysis.

As often, the original idea was not quite correct. I spoke about N-atoms rather than fractional atoms. In particular, the mass of N-molecule was N times larger than that of the ordinary molecule apart from corrections from binding energy. The more precise view about dark matter hierarchy led to the realization that fractionization of all quantum numbers occurs. In the most general case one can have fractional particles with particle number $n = k/r$, $k = 1, .., r$, $r = \frac{\hbar}{\hbar_0}$. This leaves the model essentially as such at formal level. The model is however much more

realistic than the original one since fractional atoms have mass which is never larger than that of ordinary atom and also conforms with the recent view about the origin of the hierarchy of Planck constants.

9.3.1 Dark Atoms And Dark Cyclotron States

The development of the notion of dark atom involves many side tracks which make me blush. The first naïve guess was that dark atom would be obtained by simply replacing Planck constant with its scaled counterpart in the basic formulas and interpreting the results geometrically. After some obligatory twists and turns it became clear that this assumption is indeed the most plausible one. The main source of confusion has been the lack of precise view about what the hierarchy of Planck constants means at the level of embedding space at space-time.

    The rules are very simple when one takes the singular coverings assigned to the many-valuedness of the time-derivatives of embedding space coordinates as functions of canonical momentum densities as a starting point.

1. The mass and charge of electron are fractionized as is also the reduced mass in Schrödinger equation. This implies the replacements $e \to e/r$, $m \to m/r$, and $\hbar \to r\hbar_0$, $r = n_a n_b$, in the general formula for the binding energy assigned with single sheet of the covering. If maximal number $n_a n_b$ are present corresponding to a full "Fermi sphere", the total binding energy is r times the binding energy associated with single sheet.

2. In the case of hydrogen atom the proportionality $E \propto m/\hbar^2$ implies that the binding energy for single sheet of the covering scales as $E \to E/(n_a n_b)^3$ and maximal binding energy scales as $E \to E/(n_a n_b)^2$. This conforms with the naïve guess. For high values of the nuclear charge Z it can happen that the binding energy is larger than the rest mass and fractionization might take place when binding energy is above critical fraction of the rest mass.

3. In the case of cyclotron energies one must must decide what happens to the magnetic flux. Magnetic flux quantization states that the flux is proportional to $\hbar$ for each sheet separately. Hence one has $\Phi \to r\Phi$ for each sheet and the total flux scales as r^2. Since the dimensions of the flux quantum are scaled up by r the natural scaling of the size of flux quantum is by r^2. Therefore the quantization of the magnetic flux requires the scaling $B \to B/r$. The cyclotron energy for single sheet satisfies $E \propto \hbar q B/m$ and since both mass m and charge q become fractional, the energy E for single sheet remains invariant whereas total cyclotron energy is scaled up by r in accordance with the original guess and the assumption used in applications.

4. Dark cyclotron states are expected to be stable up to temperatures which are r times higher than for ordinary cyclotron states. The states of dark hydrogen atoms and its generalizations are expected to be stable at temperatures scaled down by $1/r^2$ in the first approximation.

5. Similar arguments allow to deduce the values of binding energies in the general case once the formula of the binding energy given by standard quantum theory is known.

    The most general option option allows fractional atoms with proton and electron numbers varying from $1/r$ to 1. One can imagine also the possibility of fractional molecules. The analogs of chemical bonds between fractional hydrogen atoms with $N - k$ and k fractional electrons and protons can be considered and would give rise to a full shell of fractional electrons possessing an exceptional stability. These states would have proton and electron numbers equal to one.

    Catalytic sites are one possible candidate for fractal electrons and catalyst activity might be perhaps understood as a strong tendency of fractal electron and its conjugate to fuse to form an ordinary electron.

Connection with quantum groups?

The phase $q = exp(i2\pi/r)$ brings unavoidably in mind the phases defining quantum groups and playing also a key role in the model of topological quantum computation [K6]. Quantum groups indeed emerge from the spinor structure in the "world of classical worlds" realized as the space of

3-surfaces in $M^4 \times CP_2$ and being closely related to von Neumann algebras known as hyper-finite factors of type II_1 [K122].

Only singular coverings are allowed if the hierarchy of Planck constants and corresponding hierarchy of singular coverings follows from the basic TGD. If the integer n characterizing the quantum phase allows identification with with $r = \hbar/\hbar_0$, living matter could be perhaps understood in terms of quantum deformations of the ordinary matter, which would be characterized by the quantum phases $q = exp(i2\pi/r)$. Hence quantum groups, which have for long time suspected to have significance in elementary particle physics, might relate to the mystery of living matter and predict an entire hierarchy of new forms of matter.

How to distinguish between fractional particles and ordinary particles?

The unavoidable question is whether bio-molecules in vivo could involve actually fractional atoms molecules as their building blocks. This raises a series of related questions.

1. Could it be that we can observe only the fusion of of dark fractional fold molecules to ordinary molecules or its reversal? Is the behavior of matter matter in vivo dictated by the dark matter commentn and of matter in vitro by ordinary matter? Could just the act of observing the matter in vivo in the sense of existing science make it ordinary dead matter?

2. If fractional atoms and molecules correspond to the maximum number of fractional quanta their masses are same as for ordinary atoms and molecules and only the different binding energy photon spectrum distinguishes between them. Situation changes all fractional states are possible and one obtains scaled down spectrum as a unique signature.

3. The fusion of fractional molecules to ordinary molecules in principle allows to conclude that fractional molecule was present. Could this process mean just the replacement of DNA in vivo with DNA in vitro?

9.3.2 Spontaneous Decay And Completion Of Dark Fractional Atoms As A Basic Mechanisms Of Bio-Chemistry?

The replication of DNA has remained for me a deep mystery and I dare to doubt that the reductionistic belief that this miraculous process is well-understood involves self deceptive elements. Of course the problem is much more general: DNA replication is only a single very representative example of the miracles of un-reasonable selectivity of the bio-catalysis. I take this fact as a justification for some free imagination inspired by the notion of dark fractional molecule.

Dark fermionic molecules can replicate via decay and spontaneous completion

Unit particle number for fractional atom or molecule means that the analog of closed electronic shell are in question so that the state is especially stable. Note that the analogy with full Fermi electronic sphere makes also sense. These atoms or molecules could decay to fractional atoms or molecules. with fractional particle numbers k/r and $(r-k)/r$.

Suppose that a fractional molecule with unit particle number decays into k/r-molecule and $(r-k)/r$-molecule. If r is even it is possible to have $k = r - k = r/2$ and the situation is especially symmetric. If fermionic $k/r < 1$ fractional atoms or molecules are present, one can imagine that they tend to be completed to full molecules spontaneously. Thus spontaneous decay and completion would favor the spontaneous replication (or rather fractionization) and dark molecules could be ideal replicators (fractionizers) The idea that the mechanisms of spontaneous decay and completion of dark fractional particles somehow lurk behind DNA replication and various high precision bio-catalytic processes is rather attractive.

Reduction of lock and key mechanism to spontaneous completion

DNA replication and molecular recognition by the lock and key mechanism are the two mysterious processes of molecular biology. As a matter fact, DNA replication reduces to spontaneous opening of DNA double strand and to the lock and key mechanism so that it could be enough to understand

the opening of double strand in terms of spontaneous decay and lock and key mechanism in terms of spontaneous completion of fractional particle (-atom or -molecule).

Consider bio-molecules which fit like a lock and key. Suppose that they are accompanied by dark fractional atoms or molecules, to be called dark fractional particles in sequel, such that one has $k_1 + k_2 = r$ so that in the formation of bound state dark molecules combine to form r-molecule analogous to a full fermionic shell or full Fermi sea. This is expected to enhance the stability of this particular molecular complex and prefer it amongst generic combinations.

For instance, this mechanism would make it possible for nucleotide and its conjugate, DNA and mRNA molecule, and tRNA molecule and corresponding amino-acid to recognize each other. Spontaneous completion would allow to realize also the associations characterizing the genetic code as a map from RNAs to subset of RNAs and associations of this subset of RNAs with amino-acids (assuming that genetic code has evolved from RNA $\rightarrow$ RNA code as suggested in this chapter).

As such this mechanism allows a rather limited number of different lock and key combinations unless r is very large. There is however a simple generalization allowing to increase the representative power so that lock and key mechanism becomes analogous to a password used in computers. The molecule playing the role of lock $resp.$ molecule would be characterized by a set of n fractional particles with $k_1 \in \{k_{1,1}, ...k_{1,n}\}$ $resp.$ $k_2 \in \{k_{2,1} = r - k_{1,1}, ..., k_{2,n} = r - k_{1,n}\}$. The molecules with conjugate names would fit optimally together. Fractional molecules or fractional electrons or atoms appearing as their building blocks would be like letters of a text characterizing the name of the molecule.

The mechanism generalizes also to the case of $n > 2$ reacting molecules. The molecular complex would be defined by a partition of n copies of integer r to a sum of m integers $k_{k,i}$: $\sum_i k_{k,i} = r$.

This mechanism could provide a universal explanation for the miraculous selectivity of catalysts and this selectivity would have practically nothing to do with ordinary chemistry but would correspond to a new level of physics at which symbolic processes and representations based on dark fractional particles emerge.

Connection with the number theoretic model of genetic code?

The emergence of partitions of integers in the labelling of molecules by fractional particles suggests a connection with the number theoretical model of genetic code [K36], where DNA triplets are characterized by integers $n \in \{0, ..., 63\}$ and amino-acids by integers $0, 1$ and 18 primes $p < 64$. For instance, one can imagine that the integer n means that DNA triplet is labelled by n/r-particle. $r = 64$ would be the obvious candidate for r and conjugate DNA triplet would naturally have $n_c = 64 - n$.

The model relies on number-theoretic thermodynamics for the partitions of n to a sum of integers and genetic code is fixed by the minimization of number theoretic entropy which can be also negative and has thus interpretation as information. Perhaps these partitions could correspond to states resulting in some kind of decays of n-fermion to n_k/r-fermions with $\sum_{k=1}^{r} n_k = n$. The n_k/r-fermions should however not correspond to separate particles but something different. A possible interpretation is that partition corresponds to a state in which n_1/r particle is topologically condensed at $n_2/r \geq n_1/r$ particle topologically condensed....at $n_k/r \geq n_{k-1}/r$-particle. This would also automatically define a preferred ordering of the integers n_i in the partition.

An entire ensemble of labels would be present and depending on the situation codon could be labelled not only by n/r-particle but by any partition $n = \sum_{i=1}^{k} n_i$ corresponding to the state resulting in the decay of n/r-particle to k fractional particles.

Reduction of DNA replication to a spontaneous decay of r-particle

DNA replication could be induced by a spontaneous decay of r-particle inducing the instability of the double strand leading to a spontaneous completion of the component strands.

Strand and conjugate strand would be characterized by k_1/r-particle and $(r-k_1)/r$-particle, which combine to form r-particle as the double strand is formed. The opening of the double strand is induced by the decay of r-particle to k_1/r- and $(r - k_1)/r$-particles accompanying strand and its conjugate and after this both strands would complete themselves to double strands by the completion to r-particle.

It would be basically the stability of fractional particle which would make DNA double strand stable. Usually the formation of hydrogen bonds between strands and more generally, between the atoms of stable bio-molecule, is believed to explain the stability. Since the notion of hydrogen bond is somewhat phenomenological, one cannot exclude the possibility that these two mechanisms might be closely related to each other. I have already earlier considered the possibility that hydrogen bond might involve dark protons [K45]: this hypothesis was inspired by the finding that there seems to exist two kinds of hydrogen bonds [D56].

The reader has probably already noticed that the participating fractional molecules in the model of lock and key mechanism are like sexual partners, and if already molecules are conscious entities as TGD inspired theory of consciousness strongly suggests, one might perhaps see the formation of entangled bound states with positive number theoretic entanglement entropy accompanied by molecular experience of one-ness as molecular sex. Even more, the replication of DNA brings in also divorce and process of finding of new companions!

9.3.3 The New View About Hydrogen Bond And Water

Concretization of the above scenario leads to a new view about hydrogen bond and the role of water in bio-catalysis.

What the fractional particles labelling bio-molecules could be?

What the dark fractional particles defining the letters for the names of various bio-molecules could be? Dark fractional hydrogen atoms are the lightest candidates for the names of bio-molecules. The fusion could give rise to the hydrogen atom appearing in hydrogen bond. One could say the fractional hydrogen atoms belong to the molecules between which the hydrogen bond is formed. In absence of bond the fractional atoms would define active catalyst sites. This mechanism would also conform with the belief that hydrogen bonds guarantee the stability of bio-molecules.

This idea is not a mere speculation. The first experimental support for the notion of dark matter [K45] came from the experimental finding that water looks in atto-second time scale from the point of view of neutron diffraction and electron scattering chemically like $H_{1.5}O$: as if one fourth of protons are dark [D58, D55, D68, D36]. Dark protons would be identifiable as fractional protons. Of course, also dark hydrogen atoms can be considered.

One can imagine also a second option. The model for [I16] [K53] leads to a rather concrete view about how magnetic body controls biological body and receives sensory input from it. The model relies on the idea that dark water molecule clusters and perhaps also dark exotically ionized super-nuclei formed as linear closed strings of dark protons [K45] perform this mimicry. Dark proton super-nuclei are ideal for mimicking the cyclotron frequencies of ordinary atoms condensed to dark magnetic flux quanta. Of course, also partially ionized hydrogen fractional ions could perform the cyclotron mimicry of molecules with the same accuracy.

One can consider the possibility fractional molecules/atoms correspond to exotic atoms formed by electrons bound to exotically ionized dark super-nuclei: the sizes of these nuclei are however above atomic size scale so that dark electrons would move in a harmonic oscillator potential rather than Coulombic potential and form states analogous to atomic nuclei. The prediction would be the existence of magic electron numbers [K45]. Amazingly, there is strong experimental evidence for the existence of this kind of many-electron states. Even more, these states are able to mimic the chemistry of ordinary atoms [D65, D29, D22]. The formation of hydrogen bonds between catalyst and substrate could be the correlate for the fusion of fractional hydrogen atoms.

If the fusion process gives rise 1/1-hydrogen, its spontaneous decay to ordinary hydrogen would liberate the difference of binding energies as metabolic energy helping to overcome the energy barrier for the reaction. The liberated energy would be rather large and correspond 3.4 eV UV photon even for $r = 2$ which suggests that it does not relate with standard metabolism. For larger values of r the liberated energy rapidly approaches to the ground state energy of hydrogen. Note that the binding energy of ordinary hydrogen atom in state $n = r$ has in the lowest order approximation same energy as the ground state of dark hydrogen atom for $\hbar/\hbar_0 = r$ so that one can consider the possibility of a resonant coupling of these states.

Fractional protons and electrons have effective charge $\pm ke/r$ so that the binding regions of catalysts and reacting molecules could carry effective fractional surface charge.

This might relate in an interesting manner to the problem of how poly-electrolytes can be stable (I am grateful for Dale Trenary for pointing me the problem and for interesting discussions). For instance, DNA carries a charge of -2 units per nucleotide due to the phosphate backbone. The models trying to explain the stability involve effective binding of counter ions to the polyelectrolyte so that the resulting system has a lower charge density. The simulations of DNA condensation by Stevens [I119] however predict that counter ion charge should satisfy $z > 2$ in the case of DNA. The problem is of course that protons with $z = 1$ are the natural counter ions. The positive surface charge defined by the fractional protons attached to the nucleotides of DNA strand could explain the stability.

The hydrogen atoms in hydrogen bonds as fractional hydrogen atoms and $H_{1.5}O$ formula for water

The simplest assumption is that the hydrogens associated with hydrogen bonds are actually associated with 1/1 type dark hydrogen atoms. This hypothesis has interesting implications and could explain the formula $H_{1.5}O$ for water in atto-second time scales suggested by neutron diffraction and electron scattering [D58, D55, D68, D36].

The formation of hydrogen bond would correspond to a fusion of name and conjugate name between $H_{k/r}$-O-H atom and its conjugate $H_{(r-k)/r}$-O-H atom. The resulting pairs would obey the chemical formula H_3-O_2. Hence the formation of hydrogen bonds would predict the $H_{1.5}O$ formula suggested by neutron diffraction and electron scattering in atto-second time scale. This holds true only if one has complete pairing by hydrogen bonds. A more plausible explanation is that just the presence of fractioanl hydrogens implies the effect. Furthermore, the fraction of dark protons can depend on temperature.

The roles of water and ordered water in catalysis

The new view about hydrogen bond allows to understand the role of water in biology at qualitative level. For instance, one can

1. tentatively identify "ordered water" as a phase in which all $H_{k/r}$ atoms and their conjugates have combined to $H_{1/1}$ atoms,

2. understand why (or perhaps it is better to say "predict that") water containing $H_{k/r}$ atoms acts as a catalytic poison so that the binding sites of catalysts and reactants must be isolated from water unless the water is ordered,

3. justify the belief that gel phase involving ordered water is necessary for biological information processing,

4. understand why hydration causes hydrolysis,

5. understand the instability of DNA against decay to RNA outside nucleus.

   A more more detailed sketch looks like following.

1. Suppose that at least part of water molecules appear in form $H_{k/r}$-OH and $H_{(r-k)/r}$-O-H. These molecules and the molecule $H_{1/1}$-OH$_2$ formed in their fusion has much smaller binding energy than ordinary water molecule and is expected to be unstable against transition to H_3O. This would suggest that the feed of metabolic energy is needed to generate the dark hydrogen atoms.

   Fractional dark water molecules can join pairwise to form H-O-$(H_{1/1})$-O-H$\equiv$ H_3O_2 with $H_{1/1}$-atoms replacing hydrogen in hydrogen bond. Also $H_{k_1/r}$-O-$H_{k_2/r}$ molecules are possible and could form closed strings obeying the chemical formula $O_n(H_{1/1})_n$. Also open strings with H-O: s at ends are possible. This phase of water might allow identificaton as "ordered water" believed to be associated with gel phase and be crucial for quantal information processing inside cell. Liquid crystal phase of water could correspond to a bundle of open vertical segments H-$O_n(H_{1/1})_{n-2}$-H forming a 2-dimensional liquid (vertical freezing).

2. Exotic water molecules could spoil the action of both catalyst and reactant molecules by attaching to the "letters" in the name of catalyst or reactant so that the letters are not visible and catalyst and reactant cannot recognize each other anymore. Hence binding sites of catalyst and reactant must be isolated from water containing fractional water molecules. This is what Sidorova and Rau [I140] suggest on basis of comparison of specific and non-specific catalysts: non-specific catalysts contain water in an isolated binding volume whereas for specific catalysts this volume is empty. An alternative mechanism hindering water molecules to attach to "letters" is that water is "ordered water" with no fractional water molecules present.

3. DNA is known to be stable against decay to RNA via hydration inside the cell but not outside. Hydration could correspond to the joining of fractional water to sites of DNA transforming it to RNA. Inside nucleus this cannot occur if water is in ordered water phase permanently.

How the first self-replicators emerged?

The identification of the first self replicator can be seen as perhaps the most fascinating and challenging problem faced by the pre-biotic model builders. Self replicator is by definition an entity which catalyzes its own replication. The analogy with the self-referential statement appearing in Gödel's theorem obvious.

In TGD framework self replication would reduce to a spontaneous decay of $H_{1/1}$-atom to $H_{k/r}$- and $H_{(r-k)/r}$-atoms and their subsequent completion to $H_{1/1}$-atoms

The picture about emergence of self-replicators would be roughly following.

1. The first self-replicating entities would have been plasmoids [I107] generating $H_{1/1}$ atoms whose presence would have made possible the emergence of the first molecular self replicators. The generation of $H_{1/1}$ atoms requires metabolic energy feed. In the first approximation the decay of $H_{1,1}$ to fractional hydrogen atoms does not liberate nor require energy.

2. $H_{k/r}$ atoms would have replaced some ordinary H-atoms in some negatively charged molecules M_i (perhaps MXTP, $X = A, U, C, G$) leading to a spontaneous emergence of linear negatively charged polymers consisting of M_i. One can imagine a coding in which each X corresponds to fixed value of k or collection of the (2 hydrogen bonds or 3 hydrogen bonds depending on X). This would make the attachment of X and its conjugate to form a hydrogen bond a highly favored process.

3. $H_{k/r}$ atoms would have taken also the role of active binding sites. In ordered water conjugate molecules $M_{c,i}$ having $H_{(r-k)/r}$ atoms as labels would have had high probability to attach to the polymers made of M_i.

4. RNA molecules are good candidates for self-replicators in the presence of ordered water. The phase transition from ordinary to ordered water (which would have developed later to sol-gel phase transition) would have been an essential element of replication.

The role of water in chiral selection

In the latest New Scientist (when I am writing this) there was a news telling that chiral selection occurs in water but not in heavy water [C9]. The L form of amino-acid glutamate is more stable than R in ordinary but not so in heavy water so that water environment must be responsible for the chirality selection of bio-molecules. The proposed explanation for the finding, whose importance cannot be over-estimated, was following.

1. Water molecules have two forms: orto- and para, depending on whether the nuclear spins of protons are parallel or opposite. Deuterium nuclei are spinless so that heavy water has only single form. In thermal equilibrium the fraction of orto water is 3/4 and para water 1/4.

2. Ortho-water is magnetic and if L form of amino-acid is slightly more magnetic than R, chirality selection can be understood as result of the magnetic interaction with water.

One can of course wonder how extremely short ranged weak interactions could produce strong enough effect on the magnetic moment. The situation is not made easier by the fact that magnetic interaction energies are inherently very weak and deep below the thermal threshold.

It is interesting to find whether these findings could be explained by and allow a more detailed formulation of the TGD based model for water based on the notion of fractional hydrogen atom, the new view about hydrogen bond, and the notion of dark protonic strings forming atomic sized super-nuclei carrying exotic weak charges.

1. Dark matter brings in long ranged exotic weak interactions which can produce large parity breaking effects in atomic and even longer length scales. The long ranged parity breaking weak interactions of the dark protonic super nuclei assignable to amino-acids and water could explain the chiral selection.

2. The magnetic interaction energy is scaled up by r, so that magnetic interactions could indeed play a key role. Ordinary classical magnetic fields are in TGD framework always accompanied by Z^0 magnetic fields. If amino-acids possess exotic em charge implying also exotic weak charge, one can understand the chiral breaking as being induced by the Z^0 magnetic interaction of aminocids with the dark magnetic fields generated by water molecules or their clusters possessing a net magnetic moment. In heavy water these fields would be absent so that the experimental findings could be understood.

3. The experimental evidence that water behaves as $H_{1.5}O$ in atto-second time scales means that 1/4: th of protons of water are effectively dark. The notion of fractional hydrogen atom leads to a model of hydrogen bond predicting correctly $H_{1.5}O$ formula and the dropping of 1/4: th of protons at larger possibly dark space-time sheets. The model also predicts that the mass of $H - O - H_r - O - H \equiv 2H_{1.5}O$ hydrogen bonded pairs is very near to the mass of 2 water molecules since there are $r \simeq m_p/m_e$ electrons involved. The paired molecules have three protons and non-vanishing net nuclear spin and thus generate a magnetic field and make hydrogen bonded water a magnetic system. The natural identification would be as dark magnetic field accompanied by Z^0 magnetic field responsible for the chiral selection.

   In the case of $D - O - D_r - O - D$ mass would be by about one proton mass m_p lower than mass of two D_2O molecules so that this D-bonded heavy water would look like $D_{1.25}O$ as far as masses are considered and $D_{1.5}O$ as far neutron diffraction and electron scattering are considered. In this case no magnetic field is generated since the nuclear spin of D vanishes and no chiral breaking results. This picture explains the experimental findings. The model is not equivalent with the proposal of the experimentalists.

4. The model predicts that the protons liberated in the formation of hydrogen bonds drop to larger space-time sheets but does not specify their fate. A strong constraint comes from the requirement that the dropped particles have exotic weak charges acting as sources of the geometrically unavoidable classical Z^0 magnetic field at dark space-time sheets causing the large parity breaking. This constraint is satisfied if the protons form super-nuclei (scaled up variants of nuclei) consisting of protonic strings connected by color bonds involving exotic quark and antiquark at its ends and some of these bonds are charged (of type $u\bar{d}$ or $d\bar{u}$: this could also generate the em charge needed to make the protonic string stable.

9.4 TGD Based Model For Qualia And Sensory Receptors

The identification of quantum number increments in quantum jump for a subsystem representing sub-self and the capacitor model of sensory receptor are already more than decade old ideas.

The concrete realization of this vision is based on several ideas that I have developed during last five years.

1. The vision about dark matter as a hierarchy of phases partially labeled by the value of Planck constant led to the model of DNA as topological quantum computer [K5]. In this model magnetic flux tubes connecting DNA nucleotides with the lipids of the cell membrane define strands of the braids defining topological quantum computations. The braid strand

corresponds to so called wormhole flux tube and has quark and antiquark at its ends. u and d quarks and their antiquarks code for four DNA nucleotides in this model.

2. Zero energy ontology assigns to elementary particles so called causal diamonds (CDs). For u and d quarks and electron these time scales are (6.5, .78, 100) ms respectively, and correspond to fundamental biorhythms. Electron time scale corresponds to 10 Hz fundamental biorhythm defining also the fundamental frequency of speech organs, .78 ms to kHz cortical synchrony [J45], and 160 Hz to cerebellar synchrony [J42]. Elementary particles therefore seem to be directly associated with neural activity, language, and presumably also hearing. One outcome was the modification of the earlier model of memetic code involving the notion of cognitive neutrino pair by replacing the sequence of cognitive neutrino pairs with that of quark sub-CDs within electron CD. Nerve pulses could induce the magnetization direction of quark coding for bit but there are also other possibilities. The detailed implications for the model of nerve pulse [K92] remain to be disentangled.

3. The understanding of the Negentropy Maximization Principle [K70] and the role of negen-tropic entanglement in living matter together with the vision about life as something in the intersection of real and p-adic worlds was a dramatic step forward. In particular, space-like and time-like negentropic entanglement (see **Fig. http://tgdtheory.fi/appfigures/cat.jpg** or **Fig. ??** in the appendix of this book) become basic aspects of conscious intelligence and are expected to be especially important for understanding the difference between speech and music.

4. One of the basic challenge has been to construct a quantitative model for cell membrane.

   (a) The first model was based on the assumption that long range weak forces however play a key role [K17]. They are made possible by the exotic ground state represented as almost vacuum extremal of Kähler action for which classical em and Z^0 fields are proportional to each other whereas for the standard ground state classical Z^0 fields are very weak. Neutrinos are present but it seems that they do not define cognitive or Boolean representations in the time scales characterizing neural activity. Electrons and quarks for which the time scales of causal diamonds correspond to fundamental biorhythms - one of the key observations during last years- take this role. The essential element is that the energies of the Josephson photons are in visible range. This would explain bio-photons and even why the frequencies assignable to visual receptors. The problem is that Weinberg angle must be assumed to be much smaller in the near vacuum extremal phase than in standard model.

   (b) Second model is based on Gerald Pollack's findings about fourth phase of water and exclusion zones [L23]. These zones inspire a model for pre-biotic cells. The outcome is a modification of the simplest model of Josephson junction. Besides resting potential also the difference between cyclotron energies between the two sides of the membrane plays a key role. This model allows to understand what happens in metabolism in terms of a quantum model replacing the thermodynamical model for cell membrane with its quantal "square root" inspired by Zero Energy Ontology. The model allows also to understand bio-photons as decay products of dark photons.

   (c) The success of the latter model does not of course mean that the weak forces could not be important in cell membrane scale and the realistic model could be a hybrid of these two models. The inclusion of Z^0 contribution to the effective magnetic field could also to the fact that the endogenous magnetic field deduced from Blackman's experiments is $B_{end} = 2B_E/5$ rather than B_E (Earth's magnetic field).

9.4.1   A General Model Of Qualia And Sensory Receptor

The identification of sensory qualia in terms of quantum number increments and geometric qualia representing geometric and kinematic information in terms of moduli of CD, the assignment of sensory qualia with the membrane of sensory receptor, and capacitor model of qualia are basic ideas behind the model. The communication of sensory data to magnetic body using Josephson photons is also a key aspect of the model.

A general model of qualia

It is good to start by summarizing the general vision about sensory qualia and geometric qualia in TGD Universe.

1. The basic assumption is that sensory qualia correspond to increments of various quantum numbers in quantum jump. Standard model quantum numbers- color quantum numbers, electromagnetic charge and weak isospin, and spin are the most obvious candidates. Also cyclotron transitions changing the integer characterizing cyclotron state could corresponds to some kind of quale- perhaps "a feeling of existence". This could make sense for the qualia of the magnetic body.

2. Geometric qualia could correspond to the increments of zero modes characterizing the induced CP_2 Käjhler form of the partonic 2-surface and of the moduli characterizing the causal diamonds serving as geometric correlates of selves. This moduli space involves the position of CD and the relative position of tips as well as position in CP_2 and relative position of two CP_2 points assigned to the future and past boundaries of CD. There are good motivations for proposing that the relative positions are quantized. This gives as a special case the quantization of the scale of CD in powers of two. Position and orientation sense could would represent this kind of qualia. Also kinematical qualia like sensation of acceleration could correspond to geometric qualia in generalized 4-D sense. For instance, the sensation about motion could be coded by Lorentz boots of sub-CD representing mental image about the object.

3. One can in principle distinguish between qualia assignable to the biological body (sensory receptors in particular) and magnetic body. The basic question is whether sensory qualia can be assigned only with the sensory receptors or with sensory pathways or with both. Geometric qualia might be assignable to the magnetic body and could provide third person perspective as a geometric and kinematical map of the body and its state of motion represented using the moduli space assignable to causal diamonds (CD). This map could be provided also by the body in which case the magnetic body would only share various mental images. The simplest starting assumption consistent with neuro-science is that sensory qualia are assigned with the cell membrane of sensory receptor and perhaps also with the neurons receiving data from it carried by Josephson radiation coding for the qualia and possibly partially regenerating them if the receiving neuron has same value of membrane potential as the sensory receptor when active. Note that during nerve pulse also this values of membrane potential is achieved for some time.

Could some sensory qualia correspond to the sensory qualia of the magnetic body?

Concerning the understanding of a detailed model for how sensory qualia are generated, the basic guideline comes from the notion of magnetic body and the idea that sensory data are communicated to the magnetic body as Josephson radiation associated with the cell membrane. This leaves two options: either the primary a sensory qualia are generated at the level of sensory receptor and the resulting mental images negentropically entangle with the "feeling of existence" type mental images at the magnetic body or they can be also generated at the level of the magnetic body by Josephson radiation -possibly as cyclotron transitions. The following arguments are to-be-or-not-to-be questions about whether the primary qualia must reside at the level of sensory receptors.

1. Cyclotron transitions for various cyclotron condensates of bosonic ions or Cooper pairs of fermionic ions or elementary particles are assigned with the motor actions of the magnetic body and Josephson frequencies with the communication of the sensory data. Therefore it would not be natural to assign qualia with cyclotron transitions. One the other hand, in zero energy ontology motor action can be regarded formally as a time reversed sensory perception, which suggests that cyclotron transitions correlated with the "feeling of existence" at magnetic body entangled with the sensory mental images. They could also code for the pitch of sound as will be found but this quale is strictly speaking also a geometric quale in the 4-D framework.

2. If Josephson radiation induces cyclotron transitions, the energy of Josephson radiation must correspond to that of cyclotron transition. This means very strong additional constraint not easy to satisfy except during nerve pulse when frequencies varying from about 10^{14} Hz down to kHz range are emitted the system remains Josephson contact. Cyclotron frequencies are also rather low in general, which requires that the value of $\hbar$ must be large in order to have cyclotron energy above the thermal threshold. This would however conform with the very beautiful dual interpretation of Josephson photons in terms of bio-photons and EEG. One expects that only high level qualia can correspond to a very large values of $\hbar$ needed.

   For the sake of completeness it should be noticed that one might do without large values of $\hbar$ if the carrier wave with frequency defined by the metabolic energy quantum assignable to the kicking and that the small modulation frequency corresponds to the cyclotron frequency. This would require that Josephson frequency corresponds to the frequency defined by the metabolic quantum. This is not consistent with the fact that very primitive organisms possess sensory systems.

3. If all primary qualia are assigned to the magnetic body, Josephson radiation must include also gluons and light counterparts of weak bosons are involved besides photons. This is quite a strong additional assumption and it will be found that the identification of sensory qualia in terms of quantum numbers of quark pair restricts them to the cell membrane. The coding of qualia by Josephson frequencies is however possible and makes it possible to regenerate them in nervous system. The successful model explaining the peak frequencies of photoreceptors in terms of ionic cyclotron frequencies supports this view and provides a realization for an old idea about spectroscopy of consciousness which I had already been ready to give up.

Capacitor model of sensory qualia

In capacitor model of sensory receptor the increments of quantum numbers are amplified as particles with given quantum numbers flow between the plates of capacitor like system and the second plate defines the sub-self responsible for the mental image. The generation of complementary qualia assignable to the two plates and bringing in mind complementary colors is predicted. The capacitor is at the verge of di-electric breakdown. The interior and exterior of the receptor cell are the most plausible candidates for the capacitor plates with lipid layers defining the analog of di-electric able to changes its properties. Josephson currents generating Josephson radiation could communicate the sensory percept to the magnetic body but would not generate genuine sensory qualia there (the pitch of sound would be interpreted as a geometric quale). The coding is possible if the basic qualia correspond in one-one manner to ionic Josephson currents. There are sensory receptors which themselves do not fire (this is the case for hair cells for hearing and tactile receptor cells) and in this case the neuron next to the receptor in the sensory pathway would take the role of the quantum critical system.

The notion of sensory capacitor can be generalized. In zero energy ontology the plates could be effectively replaced with positive and negative energy parts of zero energy state or with cyclotron Bose-Einstein condensates corresponding to two different energies. Plates could also correspond to a pair of space-time sheets labeled by different p-adic primes and the generation of quale would correspond in this case to a flow of particles between the space-time sheets or magnetic flux tubes connected by contacts defining Josephson junctions.

The TGD inspired model for photoreceptors [K92] relies crucially on the assumption that sensory neurons at least and probably all cell membranes correspond to nearly vacuum extremals with the value of Weinberg angle equal to $sin^2(\theta_W) = .0295$ and weak bosons having Compton length of order cell size and ordinary value of Planck constant. This also explains the large parity breaking effects in living matter. The almost vacuum extremal property conforms with the vision about cell membrane as a quantum critical system ideal for acting as a sensory receptor.

9.4.2 Detailed Model For The Qualia

The proposed vision about qualia requires a lot of new physics provided by TGD. What leads to a highly unique proposal is the intriguing coincidence of fundamental elementary particle time scales

with basic time scales of biology and neuro science and the model of DNA as topological quantum computer [K5].

1. Zero energy ontology brings in the size scale of CD assignable to the field body of the elementary particle. Zero energy states with negentropic time-like entanglement between positive and negative energy parts of the state might provide a key piece of the puzzle. The negentropic entanglement (see **Fig.** `http://tgdtheory.fi/appfigures/cat.jpg` or **Fig. ??** in the appendix of this book) beween positive energy parts of the states associated with the sub-CD assignable to the cell membrane and sub-CD at the magnetic body is expected to be an important factor.

2. For the standard value of $\hbar$ the basic prediction would be 1 ms second time scale of d quark, 6.5 ms time scale of u quark, and .1 second time scale of electron as basic characterizes of sensory experience if one accept the most recent estimates $m(u) = 2$ MeV and $m(d) = 5$ MeV for the quark masses [C4]. These time scales correspond to 10 Hz, 160 Hz, and 1280 Hz frequencies, which all characterize neural activity (for the identification of 160 Hz frequency as cerebellar resonance frequency see [J42]). Hence quarks could be the most interesting particles as far as qualia are considered and the first working hypothesis would be that the fundamental quantum number increments correspond to those for quark-anti-quark pair. The identification in terms of quantum numbers of single quark is inconsistent with the model of color qualia.

3. The model of DNA as topological quantum computer led to the proposal that DNA nucleotides are connected to the lipids of the cell membrane by magnetic flux tubes having quark and antiquark at its ends such that the u and d quarks and their antiquarks code for the four nucleotides. The outer lipid layer was also assumed to be connected by flux tubes to the nucleotide in some other cell or in cell itself.

4. The model for DNA as topological quantum computer did not completely specify whether the flux tubes are ordinary flux tubes or wormhole flux tubes with possibly opposite signs of energy assigned with the members of the flux tube pair. Although it is not necessary, one could assume that the quantum numbers of the two parallel flux tubes cancel each other so that wormhole flux tube would be characterized by quantum numbers of quark pairs at its ends. It is not even necessary to assume that the net quantum numbers of the flux tubes vanish. Color confinement however suggests that the color quantum at the opposite ends of the flux tube are of opposite sign.

   (a) The absence of a flux tube between lipid layers was interpreted as an isolation from external world during the topological quantum computation. The emergence of the flux tube connection means halting of topological quantum computation. The flux tube connection with the external world corresponds to sensory perception at the level of DNA nucleotide in consistency with the idea that DNA plays the role of the brain of cell [K101]. The total color quantum numbers at the ends of the flux tubes were assumed to sum up to zero. This means that the fusion of the flux tubes ending to the interior and exterior cell membrane to single one creates a flux tube state not localized inside cell and that the interior of cell carries net quantum numbers. The attractive interpretation is that this process represents the generation of quale of single nucleotide.

   (b) The formation of the flux tube connection between lipid layers would involve the transformation of both quark-antiquark pairs to an intermediate state. There would be no kinematic constraints on the process nor to the mass scales of quarks. A possible mechanism for the separation of the two quark-antiquark pairs associated with the lipids from the system is double reconnection of flux tubes which leads to a situation in which the quark-antiquark pairs associated with the lipid layers are connected by short flux loops and separated to a disjoint state and there is a long wormhole flux tube connecting the nucleotides possibly belonging to different cells.

   (c) The state of two quark pairs need not have vanishing quantum numbers and one possibility is that the quantum numbers of this state code for qualia. If the total numbers of flux tubes are vanishing also the net quantum numbers of the resulting long flux tube

connecting two different cells provide equivalent coding. A stronger condition is that this state has vanishing net quantum numbers and in this case the ends of the long flux tube would carry opposite quantum numbers. The end of flux tube at DNA nucleotide would characterize the quale.

5. Two identification of primary qualia are therefore possible.

    (a) If the flux tubes have vanishing net quantum numbers, the primary sensory quale can be assigned to single receptor cell and the flow of the quantum numbers corresponds to the extension of the system with vanishing net quantum numbers in two-cell system.

    (b) If the net quantum numbers of the flux tube need not vanish, the resulting two cell system carries non-vanishing quantum numbers as the pair of quark-antiquark pairs removes net quantum numbers out of the system.

6. If the net quantum numbers for the flux tubes vanish always, the specialization of the sensory receptor membrane to produce a specific quale would correspond to an assignment of specific quantum numbers at the DNA ends of the wormhole flux tubes attached to the lipid layers of the cell membrane. The simplest possibility that one can imagine is that the outer lipid layer is connected to the conjugate DNA nucleotide inside same cell nucleus. This option would however assign vanishing net quantum number increments to the cell as whole and is therefore unacceptable.

7. The formation of a temporary flux tube connection with another cell is necessary during the generation of quale and the question is what kind of cell is in question. The connection of the receptor to cells along the sensory pathway are expected to be present along the entire sensory pathway from DNA nucleotide to a nucleotide in the conjugate strand of second neuron to DNA nucleotide of the third neutron.... If Josephson photons are able to regenerate the quale in second neuron this would make it possible to replicate the quale along entire sensory pathway. The problem is that Josephson radiation has polarization orthogonal to axons and must propagate along the axon whereas the flux tube connection must be orthogonal to axon. Hence the temporary flux tube connection is most naturally between receptor cells and would mean horizontal integration of receptor cells to a larger structure. A holistic process in directions parallel and orthogonal to the sensory pathway would be in question. Of course, the flux tube could be also curved and connect the receptor to the next neuron along the sensory pathway.

8. The specialization of the neuron to sensory receptor would require in the framework of positive energy ontology that -as far as qualia assignable to the electro-weak quantum numbers are considered - all DNA nucleotides are identical by the corresponds of nucleotides with quarks and antiquarks. This cannot be the case. In zero energy ontology and for wormhole flux tubes it is however enough to assume that the net electroweak quantum numbers for the quark antiquark pairs assignable to the DNA wormhole contact are same for all nucleotides. This condition is easy to satisfy. It must be however emphasized that there is no reason to require that all nucleotides involved generate same quale and at the level of neurons sensory maps assigning different qualia to different nucleotides and lipids allowing DNA to sensorily perceive the external world are possible.

The model should be consistent with the assignment of the fundamental bio-rhythms with the CDs of electron and quarks.

1. Quark color should be free in long enough scales and cellular length scales are required at least. The QCD in question should therefore have long enough confinement length scales. The first possibility is provided by almost vacuum extremals with a long confinement scale also at the flux tubes. Large $\hbar$ for the cell membrane space-time sheet seems to be unavoidable and suggests that color is free in much longer length scale than cell length scale.

2. Since the length of the flux tubes connecting DNA and cell membrane is roughly 1 micrometer and by a factor of order 10^7 longer than the d quark Compton length, it seems that the value of Planck constant must be of this order for the flux tubes. This however scales up the time

scale of d quark CD by a factor of 10^{14} to about 10^4 years! The millisecond and 160 ms time scales are much more attractive. This forces to ask what happens to the quark-anti-quark pairs at the ends of the tubes.

3. The only possibility seems to be that the reconnection process involves a phase transition in which the closed flux tube structure containing the two quark pairs assignable to the wormhole contacts at lipid layers is formed and leaks to the page of the Big Book with pages partially labeled by the values of Planck constant. This page would correspond to the standard value of Planck constant so that the corresponding d quark CDs would have a duration of millisecond. The reconnection leading to the ordinary situation would take place after millisecond time scale. The standard physics interpretation would be as a quantum fluctuation having this duration. This sequence of quark sub-CDs could define what might be called memetic codon representation of the nerve pulse sequence.

4. One can also consider the possibility is that near vacuum extremals give rise to a copy of hadron physics for which the quarks associated with the flux tubes are light. The Gaussian Mersennes corresponding to $k = 151, 157, 163, 167$ define excellent p-adic time scales for quarks and light variants of weak gauge bosons. Quark mass 5 MeV would with $k = 120$ would be replaced with $k = 163$ (167) one would have mass 1.77 eV (.44 eV). Small scaling of both masses gives 2 eV and .5 eV which correspond to basic metabolic quanta in TGD framework. For quark mass of 2 MeV with $k = 123$ $k = 163$ (167) one would give masses .8 eV (.05 eV). The latter scale correspond to Josephson energy assignable with the membrane potential in the ordinary phase.

In this case a phase transition transforming almost vacuum extremal to ordinary one takes place. What this would mean that the vacuum extremal property would hold true below much shorter p-adic length scale. In zero energy ontology the scaling up of quark masses is in principle possible. This option looks however too artificial.

9.4.3 Overall View About Qualia

This picture leads to the following overall view about qualia. There are two options depending on whether single quark-antiquark pair or two of them labels the qualia. In the following only the simpler option with single quark-antiquark pair is discussed.

1. All possible pairings of spin and electroweak isospin (or em charge) define 16 basic combinations if one assumes color singletness. If arbitrary color is allowed, there is a nine-fold increase of quantum numbers decomposable to color singlet and octet qualia and further into 3×15 qualia with vanishing increments of color quantum numbers and 6×16 qualia with non-vanishing increments of color quantum numbers. The qualia with vanishing increments for electroweak quantum numbers could correspond to visual colors. If electroweak quantum numbers of the quark-anti-quark pair vanish, one has 3×7 *resp.* 6×8 combinations of colorless *resp.* colored qualia.

2. There is a huge number of various combinations of these fundamental qualia if one assumes that each nucleotide defines its own quale and fundamental qualia would be analogous to constant functions and more general qualia to general functions having values in the space with $9 \times 16 - 1$ points. Only a very small fraction of all possible qualia could be realized in living matter unless the neurons in brain provide representations of body parts or of external world in terms of qualia assignable to lipid-nucleotide pairs. The passive DNA strand would be ideal in this respect.

3. The basic classification of qualia is as color qualia, electro-weak quale, and spin quale and products of these qualia. Also combinations of color qualiaandelectroweak and spin quale are possible and could define exotic sensory qualia perhaps not yet realized in the evolution. Synesthesia is usually explained in terms of sensory leakage between sensory pathways and this explanation makes sense also in TGD framework if there exists a feedback from the brain to the sensory organ. Synesthesia cannot however correspond to the product qualia: for "quantum synesthesia" cross association works in both directions and this distinguishes it from the ordinary synesthesia.

4. The idea about brain and genome as holograms encourages to ask whether neurons or equivalently DNA could correspond to sensory maps with individual lipids representing qualia combinations assignable to the points of the perceptive field. In this framework quantum synesthesia would correspond to the binding of qualia of single nucleotide (or lipid) of neuron cell membrane as a sensory representation of the external world. DNA is indeed a holographic representation of the body (gene expression of course restricts the representation to a part of organism). Perhaps it is this kind of representation also at the level of sensory experience so that all neurons could be little sensory copies of body parts as holographic quantum homunculi. In particular, in the associative areas of the cortex neurons would be quantum synesthetes experiencing the world in terms of composite qualia.

5. The number of flux tube connections generated by sensory input would code for the intensity of the quale. Josephson radiation would do the same at the level of communications to the magnetic body. Also the temporal pattern of the sequence of quale mental images matters. In the case of hearing this would code for the rhythmic aspects and pitch of the sound.

9.4.4 About Detailed Identification Of The Qualia

One can make also guesses about detailed correspondence between qualia and quantum number increments.

1. Visual colors would correspond to the increments of only color quantum numbers. Each biologically important ion would correspond to its own color increment in one-one correspondence with the three pairs of color-charged gluons and these would correspond to blue-yellow, red-green, and black white [K92]. Black-white vision would mean a restriction to the $SU(2)$ subgroup of color group. The model for the cell membrane as a nearly vacuum extremal assigns the peak frequencies corresponding to fundamental colors with biologically important ions. Josephson radiation could induce artificially the same color qualia in other neurons and this might provide an manner to communicate the qualia to the brain where they could be re-experienced at neuronal level. Some organisms are able to perceive also the polarization of light. This requires receptors sensitive to polarization. The spin of quark pair would naturally code for polarization quale.

2. Also tastes and odours define qualia with "colors". Certainly the increments of electroweak numbers are involved but since these qualia do not have any directional flavor, spin is probably not involved. This would give c 3×4 basic combinations are possible and can certainly explain the 5 or 6 basic tastes (counted as the number of different receptors). Whether there is a finite number of odours or not has been a subject of a continual debate and it might be that odours already correspond to a distribution of primary qualia for the receptor cell. That odours are coded by nerve pulse patterns for a group of neurons [J93] would conform with this picture.

3. Hearing seems to represent a rather colorless quale so that electroweak isospin suggests again itself. If we had a need to hear transversely polarized sound also spin would be involved. Cilia are involved also with hair cells acting as sensory receptors in the auditory system and vestibular system. In the case of hearing the receptor itself does not fire but induces a firing of the higher level neuron. The temporal pattern of qualia mental images could define the pitch of the sound whereas the intensity would correspond to the number of flux tube connections generated.

   The modulation of Josephson frequencies -rather than Josephson frequencies as such- would code for the pitch and the total intensity of the Josephson radiation for the intensity of the sound and in fact any quale. Pitch represents non-local information and the qualia sub-selves should be negentropically entangled in time direction. If not, the experience corresponds to a sequence of sound pulses with no well-defined pitch and responsible for the rhythmic aspects of music. Right brain sings-left brain talks metaphor would suggests that right and left brain have different kind of specializations already at the level of sensory receptors.

4. Somato-sensory system gives rise to tactile qualia like pain, touch, temperature, proprioception (body position). There are several kinds of receptors: nocireceptors, mechanoreceptors,

thermoreceptors, etc... Many of these qualia have also emotional coloring and it might be that the character of entanglement involved (negentropic/entropic defines the emotional color of the quale. If this is the case, one might consider a pure quale of touch as something analogous to hearing quale. One can argue that directionality is basic aspect of some of these qualia -say sense of touch- so that spin could be involved besides electroweak quantum numbers. The distribution of these qualia for the receptor neuron might distinguish between different tactile qualia.

9.4.5   Recent TGD based view about qualia

The TGD inspired theory of qualia [K50] has evolved gradually and the recent view differs from the above described picture in some aspects.

1. The original vision was that qualiaandother aspects of consciousness experience are determined by the change of quantum state in the reduction: the increments of quantum numbers would determine qualia. I had not yet realized that repeated state function reduction (Zeno effect) realized in ZEO is central for consciousness. The objection was that qualia change randomly from reduction to reduction.

2. Later I ended up with the vision that the rates for the changes of quantum numbers would determine qualia: this idea was realized in terms of sensory capacitor model in which qualia would correspond to kind of generalized di-electric breakdown feeding to subsystem responsible for quale quantum numbers characterizing the quale. The Occamistic objection is that the model brings in an additional element not present in quantum measurement theory.

3. The view that emerged while writing the critics of IIT of Tononi is that qualia correspond to the quantum numbers measured in the state function reduction. That in ZEO the qualia remain the same for the entire sequence of repeated state function reductions is not a problem since qualia are associated with sub-self (sub-CD), which can have lifetime of say about .1 seconds! Only the generalization of standard quantum measurement theory is needed to reduce the qualia to fundamental physics. This for instance supports the conjecture that visual colors correspond to QCD color quantum numbers. This makes sense in TGD framework predicting a scaled variants of QCD type physics even in cellular length scales.

   This view implies that the model of sensory receptor based on the generalization of di-electric breakdown [K70] is wrong as such since the rate for the transfer of the quantum numbers would not define the quale. A possible modification of the model simple: the analog of di-electric breakdown generates Bose-Einstein condensate and the quantum numbers for the BE condensate give rise to qualia assignable to sub-self.

9.5   Could Cell Membrane Correspond To Almost Vacuum Extremal?

The question whether cell membrane or even cell could correspond almost vacuum extremal of Kähler action (in some cases) was the question which led to the realization that the frequencies of peak sensitivity for photoreceptors correspond to the Josephson frequencies of biologically important ions if one accepts that the value of the Weinberg angle equals to $sin^2(\theta_W) = .0295$ instead of the value .23 in the normal phase, in which the classical electromagnetic field is proportional to the induced Kähler form of CP_2 in a good approximation. Another implication made possible by the large value of Planck constant is the identification of Josephson photons as the counterparts of bio-photons one one hand and those of EEG photons on the other hand. These observation in turn led to a detailed model of sensory qualia and of sensory receptor. Therefore the core of this argument deserves to be represented also here although it has been discussed in [K92].

9.5.1   Cell Membrane As Almost Vacuum Extremal

Although the fundamental role of vacuum extremals for quantum criticality and life has been obvious from the beginning, it took a long time to realize how one could model living cell as this

kind of system.

1. Classical electric fields are in a fundamental role in biochemistry and living biosystems are typically electrets containing regions of spontaneous electric polarization. Fröhlich [J80] proposed that oriented electric dipoles form macroscopic quantum systems with polarization density serving as a macroscopic order parameter. Several theories of consciousness share this hypothesis. Experimentally this hypothesis has not been verified.

2. TGD suggests much more profound role for the unique di-electric properties of the biosystems. The presence of strong electric dipole fields is a necessary prerequisite for cognition and life and could even force the emergence of life. Strong electric fields imply also the presence of the charged wormhole BE condensates: the surface density of the charged wormholes on the boundary is essentially equal to the normal component of the electric field so that wormholes are in some sense "square root" of the dipole condensate of Fröhlich! Wormholes make also possible pure vacuum polarization type dipole fields: in this case the magnitudes of the em field at the two space-time sheets involved are same whereas the directions of the fields are opposite. The splitting of wormhole contacts creates fermion pairs which might be interpreted as cognitive fermion pairs. Also microtubules carry strong longitudinal electric fields. This formulation emerged much before the identification of ordinary gauge bosons and their superpartners as wormhole contacts.

Cell membrane is the basic example about electret and one of the basic mysteries of cell biology is the resting potential of the living cell. Living cell membranes carry huge electric fields: something like 10^7 Volts per meter. For neuron resting potential corresponds to about .07 eV energy gained when unit charge travels through the membrane potential. In TGD framework it is not at all clear whether the presence of strong electromagnetic field necessitates the presence of strong Kähler field. The extremely strong electric field associated with the cell membrane is not easily understood in Maxwell's theory and almost vacuum extremal property could change the situation completely in TGD framework.

1. The configuration could be a small deformation of vacuum extremal so that the system would be highly critical as one indeed expects on basis of the general visiona about living matter as a quantum critical system. For vacuum extremals classical em and Z^0 fields would be proportional to each other. The second half of Maxwell's equations is not in general satisfied in TGD Universe and one cannot exclude the presence of vacuum charge densities in which case elementary particles as the sources of the field would not be necessarily. If one assumes that this is the case approximately, the presence of Z^0 charges creating the classical Z^0 fields is implied. Neutrinos are the most candidates for the carrier of Z^0 charge. Also nuclei could feed their weak gauge fluxes to almost non-vacuum extremals but not atomic electrons since this would lead to dramatic deviations from atomic physics. This would mean that weak bosons would be light in this phase and also Weinberg angle could have a non-standard value.

2. There are also space-time surfaces for CP_2 projection belongs to homologically non-trivial geodesic sphere. In this case classical Z^0 field can vanish [L2], [L2] and the vision has been that it is sensible to speak about two basic configurations.

   (a) Almost vacuum extremals (homologically trivial geodesic sphere).

   (b) Small deformations of non-vacuum extremals for which the gauge field has pure gauge Z^0 component (homologically non-trivial geodesic sphere).

   The latter space-time surfaces are excellent candidates for configurations identifiable as TGD counterparts of standard electroweak physics. Note however that the charged part of electroweak fields is present for them.

3. To see whether the latter configurations are really possible one must understand how the gauge fields are affected in the color rotation.

(a) The action of color rotations in the holonomy algebra of CP_2 is non-trivial and corresponds to the action in $U(2)$ sub-group of $SU(3)$ mapped to $SU(2)_L \times U(1)$. Since the induced color gauge field is proportional to Kähler form, the holonomy is necessary Abelian so that also the representation of color rotations as a sub-group of electro-weak group must correspond to a local $U(1)$ sub-group local with respect to CP_2 point.

(b) Kähler form remains certainly invariant under color group and the right handed part of Z^0 field reducing to $U(1)_R$ sub-algebra should experience a mere Abelian gauge transformation. Also the left handed part of weak fields should experience a local $U(1)_L$ gauge rotation acting on the neutral left handed part of Z^0 in the same manner as it acts on the right handed part. This is true if the $U(1)_L$ sub-group does not depend on point of CP_2 and corresponds to Z^0 charge. If only Z^0 part of the induced gauge field is non-vanishing as it can be for vacuum extremals then color rotations cannot change the situation. If Z^0 part vanishes and non-vacuum extremal is in question, then color rotation rotation of W components mixing them but acts as a pure $U(1)$ gauge transformation on the left handed component.

(c) It might not be without importance that for any partonic 2-surface induced electroweak gauge fields have always U(1) holonomy, which could allow to define what neutral part of induced electroweak gauge field means locally. This does not however hold true for the 4-D tangent space distribution. In any case, the cautious conclusion is that there are two phases corresponding to nearly vacuum extremals and small deformations of extremals corresponding to homologically non-trivial geodesic spheres for which the neutral part of the classical electro-weak gauge field reduces to photon field.

4. The unavoidable presence of long range Z^0 fields would explain large parity breaking in living matter, and the fact that neutrino Compton length is of the order of cell size would suggest the possibility that within neutrino Compton electro-weak gauge fields or even longer scales could behave like massless fields. The explanation would be in terms of the different ground state characterized also by a different value of Weinberg angle. For instance, of the p-adic temperature of weak bosons corresponds to $T_p = 1/2$, the mass scale would be multiplied by a factor $\sqrt{M_{89}}$ and Compton lengths of weak bosons would be around 10^{-4} meters corresponding to the size scale of a large neuron. If the value of Planck constant is also large then the Compton length increases to astrophysical scale.

5. From the equations for classical induced gauge fields in terms of Kähler form and classical Z^0 field [L2] , [L2]

$$\gamma = 3J - \frac{p}{2}Z^0 \ , \quad Q_Z = I_L^3 - pQ_{em} \ , \quad p = sin^2(\theta_W) \qquad (9.5.1)$$

it follows that for the vacuum extremals the part of the classical electro-weak force proportional to the electromagnetic charge vanishes for $p = 0$ so that only the left-handed couplings to the weak gauge bosons remain. The absence of electroweak symmetry breaking and vanishing or at least smallness of p would make sense below the Compton length of dark weak bosons. If this picture makes sense it has also implications for astrophysics and cosmology since small deformations of vacuum extremals are assumed to define the interesting extremals. Dark matter hierarchy might explain the presence of unavoidable long ranged Z^0 fields as being due to dark matter with arbitrarily large values of Planck constant so that various elementary particle Compton lengths are very long.

6. The simplest option is that the dark matter -say quarks with Compton lengths of order cell size and Planck constant of order $10^7\hbar_0$ - are responsible for dark weak fields making almost vacuum extremal property possible. The condition that Josephson photons correspond to EEG frequencies implys $\hbar \sim 10^{13}\hbar_0$ and would mean the scaling of intermediate gauge boson Compton length to that corresponding to the size scale of a larger neuron. The quarks involved with with DNA as topological quantum computer model could be in question and membrane potential might be assignable to the magnetic flux tubes. The ordinary ionic

currents through cell membrane -having no coupling to classical Z^0 fields and not acting as its sourse- would be accompanied by compensating currents of dark fermions taking care that the almost vacuum extremal property is preserved. The outcome would be large parity breaking effects in cell scale from the left handed couplings of dark quarks and leptons to the classical Z^0 field. The flow of Na$^+$ ions during nerve pulse could take along same dark flux tube as the flow of dark quarks and leptons. This near vacuum extremal property might be fundamental property of living matter at dark space-time sheets at least.

Could nuclei and neutrinos couple to light variants of weak gauge fields in the critical phase?

One of the hard-to-kill ideas of quantum TGD inspired model of quantum biology is that neutrinos might have something do with hearing and cognition. This proposal looks however unrealistic in the recent vision. I would be more than happy to get rid of bio-neutrinos but the following intriguing finding does not allow me to have this luxury.

1. Assume that the endogenous magnetic field $B_{end} = .2$ Gauss is associated with a nearly vacuum extremal and therefore accompanied by $B_Z = 2B_{end}/p$. Assume for definiteness $m_\nu = .3$ eV and $p = sin^2(\theta_W) = .23$. The neutrino cyclotron frequency is given by the following expression

$$f_\nu = \frac{m_e}{m_\nu} \frac{1}{2sin^2(\theta_W)} f_e \ .$$

   From $f_e \simeq .57\times$ MHz and $p = sin^2(\theta_W) = .23$ one obtains $E_\nu = 1.7 \times 10^{-2}$ eV, which is roughly one third to the Josephson frequency of electron assignable to cell membrane. Could Josephson frequency of cell membrane excite neutrino cyclotron transitions?

2. The model for photoreceptors to be discussed below forces to conlude that the value of Weinberg angle in the phase near vacuum extremal must be $p = .0295$ if one wants to reproduces the peak energies of photoreceptors as Josephson frequencies of basic biological ions. This would predict $E_\nu = .41$ eV, which is rather near to the metabolic energy quantum. The non-relativistic formula however fails in this case and one must use the relativistic formula giving

$$E = \sqrt{g_Z Q_Z B_Z 2\pi} \simeq .48 \ eV$$

   giving the metabolic energy quantum. Does this mean that Z^0 cyclotron frequency for neutrino is related to the transfer of metabolic energy using Z^0 MEs in the phase near vacuum extremals.

3. Josephson frequency is proportional to $1/\hbar$, whereas neutrino cyclotron frequency does not depend on $\hbar$ at non-relativistic energies. For larger values of $\hbar$ the neutrino becomes relativistic so that the mass in the formula for cyclotron frequency must be replaced with energy. This gives
$$E = \sqrt{n} r^{1/2} \sqrt{g_Z Q_Z B_Z 2\pi} \simeq r^{1/2} \times .48 \ eV \ , \ r = \sqrt{\hbar/\hbar_0} \ .$$

   Here n refers to the cyclotron harmonic.

   These observations raise the question whether the three frequencies with maximum response assignable to the three different types of receptors of visible light in retina could correspond to the three cyclotron frequencies assignable to the three neutrinos with different mass scales? The first objection is that the dependence on mass disappears completely at the relativistic limit. The second objection is that the required value value of Planck constant is rather small and far from being enough to have electroweak boson Compton length of order cell size. One can of course ask whether the electroweak gauge bosons are actually massless inside almost vacuum extremals. If fermions -including neutrino- receive their masses from p-adic thermodynamics then massless electroweak gauge bosons would be consistent with massive fermions. Vacuum extremals are indeed analogous to the unstable extrema of Higgs potential at which the Higgs vacuum expecation vanishes so that this interpretation might make sense.

Ionic Josephson frequencies defined by the resting potential for nearly vacuum extremals

If cell membrane corresponds to an almost vacuum extremal, the membrane potential potential is replaced with an effective resting potential containing also the Z^0 contribution proportional to the ordinary resting potential. The surprising outcome is that one could understand the preferred frequencies for photo-receptors [J12] as Josephson frequencies for biologically important ions. Furthermore, most Josephson energies are in visible and UV range and the interpretation in terms of bio-photons is suggestive. If the value of Planck constant is large enough Josephson frequencies are in EEG frequency range so that bio-photons and EEG photons could be both related to Josephson photons with large $\hbar$.

1. One must assume that the interior of the cell corresponds to many fermion state -either a state filled with neutrinos up to Fermi energy or Bose-Einstein condensate of neutrino Cooper pairs creating a harmonic oscillator potential. The generalization of nuclear harmonic oscillator model so that it applies to multi-neutrino state looks natural.

2. For exact vacuum extremals elementary fermions couple only via left-handed isospin to the classical Z^0 field whereas the coupling to classical em field vanishes. Both K_+, Na_+, and Cl_- $A - Z = Z + 1$ so that by p-n pairing inside nucleus they have the weak isospin of neuron (opposite to that of neutrino) whereas Ca_{++} nucleus has a vanishing weak isospin. This might relate to the very special role of Ca_{++} ions in biology. For instance, Ca_{++} defines an action potential lasting a time of order .1 seconds whereas Na_+ defines a pulse lasting for about 1 millisecond [J3]. These time scales might relate to the time scales of CDs associated with quarks and electron.

3. The basic question is whether only nuclei couple to the classical Z^0 field or whether also electrons do so. If not, then nuclei have a large effective vector coupling to em field coming from Z^0 coupling proportional to the nuclear charge increasing the value of effective membrane potential by a factor of order 100. If both electrons and nuclei couple to the classical Z^0 field, one ends up with difficulties with atomic physics. If only quarks couple to the Z^0 field and one has $Z^0 = -2\gamma/p$ for vacuum extremals, and one uses average vectorial coupling $\langle I_L^3 \rangle = \pm 1/4$ with + for proton and - for neutron, the resulting vector coupling is following

$$
\begin{aligned}
(\frac{Z-N}{4} - pZ)Z^0 + q_{em}\gamma &= Q_{eff}\gamma \ , \\
Q_{eff} &= -\frac{Z-N}{2p} + 2Z + q_{em} \ .
\end{aligned}
\tag{9.5.2}
$$

Here γ denotes em gauge potential. For K^+, Cl^-, Na^+, Ca^{++} one has $Z = (19, 17, 11, 20)$, $Z - N = (-1, -1, -1, 0)$, and $q_{em} = (1, -1, 1, 2)$. **Table 9.1** below gives the values of Josephson energies for some values of resting potential for $p = .23$. Rather remarkably, they are in IR or visible range. This is basically due to the large value of weak isospin for nuclei.

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9.5.2   Are Photoreceptors Nearly Vacuum Extremals?

In Hodgkin-Huxley model ionic currents are Ohmian currents. If one accepts the idea that the cell membrane acts as a Josephson junction, there are also non-dissipative oscillatory Josephson currents of ions present, which run also during flow equilibrium for the ionic parts of the currents. A more radical possibility is that the dominating parts of the ionic currents are oscillatory Josephson currents so that no metabolic energy would be needed to take care that density gradients for ions are preserved. Also in this case both nearly vacuum extremals and extremals with nearly vanishing Z^0 field can be considered. Since sensory receptors must be highly critical the natural question is whether they could correspond to nearly vacuum extremals. The quantitative success of the following model for photoreceptors supports this idea.

$E(Ion)/eV$	$V = -40\ mV$	$V = -60\ mV$	$V = -70\ mV$
Na^+	1.01	1.51	1.76
Cl^-	1.40	2.11	2.46
K^+	1.64	2.47	2.88
Ca^{++}	1.68	2.52	2.94

Table 9.1: Values of the Josephson energy of cell membrane for some values of the membrane voltage for $p = .23$. The value $V = -40$ mV corresponds to the resting potential for photoreceptors and $V = -70$ mV to the resting state of a typical neuron.

Photoreceptors can be classified to three kinds of cones responsible for color vision and rods responsible for black-white vision. The peak sensitivities of cones correspond to wavelengths (405, 535, 565) nm and energies (3.06, 2.32, 2.19) eV. The maximum absorption occurs in the wave length range 420-440 nm, 534-545 nm, 564-580 nm for cones responsible for color vision and 498 nm for rods responsible black-white vision [L59, J12]. The corresponding photon energies are (2.95, 2.32, 2.20) eV for color vision and to 2.49 eV for black-white vision. For frequency distribution the maxima are shifted from these since the maximum condition becomes $dI/d\lambda + 2I/\lambda = 0$, which means a shift to a larger value of λ, which is largest for smallest λ. Hence the energies for maximum absorbance are actually lower and the downwards shift is largest for the highest energy.

From **Table 9.1** it is clear that the energies of Josephson photons are in visible range for reasonable values of membrane voltages, which raises the question whether Josephson currents of nuclei in the classical em and Z^0 fields of the cell membrane could relate to vision.

Consider first the construction of the model.

1. Na^+ and Ca^{++} currents are known to present during the activation of the photoreceptors. Na^+ current defines the so called dark current [J12] reducing the membrane resting potential below its normal value and might relate to the sensation of darkness as eyes are closed. Hodgkin-Huxley model predicts that also K^+ current is present. Therefore the Josephson energies of these three ion currents are the most plausible correlates for the three colors.

2. One ends up with the model in the following manner. For Ca^{++} the Josephson frequency does not depend on p and requiring that this energy corresponds to the energy 2.32 eV of maximal sensitivity for cones sensitive to green light fixes the value of the membrane potential during hyper-polarization to $V = .055$ V, which is quite reasonable value. The value of the Weinberg angle parameter can be fixed from the condition that other peak energies are reproduced optimally. The result of $p = .0295$.

The predictions of the model come as follows summarized also by the **Table 9.2**.

1. The resting potential for photoreceptors is $V = -40$ mV [J15]. In this case all Josephson energies are below the range of visible frequencies for $p = .23$. Also for maximal hyper-polarization Na^+ Josephson energy is below the visible range for this value of Weinberg angle.

2. For $V = -40$ mV and $p = .0295$ required by the model the energies of Cl^- and K^+ Josephson photons correspond to red light. 2 eV for Cl^- corresponds to a basic metabolic quantum. For Na^+ and Ca^{++} the wave length is below the visible range. Na^+ Josephson energy is below visible range. This conforms with the interpretation of Na^+ current as a counterpart for the sensation of darkness.

3. For $V = -55$ mV - the threshold for the nerve pulse generation- and for $p = .0295$ the Josephson energies of Na^+, Ca^{++}, and K^+ a correspond to the peak energies for cones sensitive to red, green, and blue respectively. Also Cl^- is in the blue region. Ca^{++} Josephson energy can be identified as the peak energy for rods. The increase of the hyper-polarization to $V = -59$ mV reproduces the energy of the maximal wave length response exactly. A possible interpretation is that around the criticality for the generation of the action potential ($V \simeq -55$ mV) the qualia would be generated most intensely since the Josephson currents

Ion	Na^+	Cl^-	K^+	Ca^{++}
$E_J(.04\ mV, p = .23)/eV$	1.01	1.40	1.51	1.76
$E_J(.065\ V, p = .23)/eV$	1.64	2.29	2.69	2.73
$E_J(40\ mV, p = .0295)/eV$	1.60	2.00	2.23	1.68
$E_J(50\ mV, p = .0295)/eV$	2.00	2.49	2.79	2.10
$E_J(55\ mV, p = .0295)/eV$	2.20	2.74	3.07	2.31
$E_J(65\ mV, p = .0295)/eV$	2.60	3.25	3.64	2.73
$E_J(70\ mV, p = .0295)/eV$	2.80	3.50	3.92	2.94
$E_J(75\ mV, p = .0295)/eV$	3.00	3.75	4.20	3.15
$E_J(80\ mV, p = .0295)/eV$	3.20	4.00	4.48	3.36
$E_J(90\ mV, p = .0295)/eV$	3.60	4.50	5.04	3.78
$E_J(95\ mV, p = .0295)/eV$	3.80	4.75	5.32	3.99
Color	R	G	B	W
E_{max}	2.19	2.32	3.06	2.49
energy-interval/eV	1.77-2.48	1.97-2.76	2.48-3.10	

Table 9.2: Table gives the prediction of the model of photoreceptor for the Josephson energies for typical values of the membrane potential. For comparison purposes the energies E_{max} corresponding to peak sensitivities of rods and cones, and absorption ranges for rods are also given. R, G, B, W refers to red, green, blue, white. The values of Weinberg angle parameter $p = sin^2(\theta_W)$ are assumed to be .23 and .0295. The latter value is forced by the fit of Josephson energies to the known peak energies if one allows that ions - rather than their Cooper pairs - are charge carriers.

would be strongest and induce Josephson radiation inducing the quale in other neurons of the visual pathway at the verge for the generation of action potential. This supports the earlier idea that visual pathways defines a neural window. Josephson radiation could be interpreted as giving rise to bio-photons (energy scale is correct) and to EEG photons (for large enough values of $\hbar$ the frequency scales is that of EEG).

4. In a very bright illumination the hyper-polarization is $V = -65$ mV [J15], which the normal value of resting potential. For this voltage Josephson energies are predicted to be in UV region except in case of Ca^{++}. This would suggests that only the quale "white" is generated at the level of sensory receptor: very intense light is indeed experienced as white.

The model reproduces basic facts about vision assuming that one accepts the small value of Weinberg angle, which is indeed a natural assumption since vacuum extremals are analogous to the unstable extrema of Higgs potential and should correspond to small Weinberg angle. It deserves to be noticed that neutrino Josephson energy is 2 eV for $V = -50$ mV, which correspond to color red. 2 eV energy defines an important metabolic quantum.

It interesting to try to interpret the resting potentials of various cells in this framework in terms of the Josephson frequencies of various ions.

1. The maximum value of the action potential is $+40$ mV so that Josephson frequencies are same as for the resting state of photoreceptor. Note that the time scale for nerve pulse is so slow as compared to the frequency of visible photons that one can consider that the neuronal membrane is in a state analogous to that of a photoreceptor.

2. For neurons the value of the resting potential is -70 mV. Na^+ and Ca^{++} Josephson energies 2.80 eV and 2.94 eV are in the visible range in this case and correspond to blue light. This does not mean that Ca^{++} Josephson currents are present and generate sensation of blue at neuronal level: the quale possibly generated should depend on sensory pathway. During the hyper-polarization period with -75 mV the situation is not considerably different.

3. The value of the resting potential is -95 mV for skeletal muscle cells. In this case Ca^{++} Josephson frequency corresponds to 4 eV metabolic energy quantum as **Table 9.1** shows.

4. For smooth muscle cells the value of resting potential is -50 mV. In this case Na^+ Josephson frequency corresponds to 2 eV metabolic energy quantum.

5. For astroglia the value of the resting potential is -80/-90 mV for astroglia. For -80 mV the resting potential for Cl^- corresponds to 4 eV metabolic energy quantum. This suggests that glial cells could also provide metabolic energy as Josephson radiation to neurons.

6. For all other neurons except photo-receptors and red blood cells Josephson photons are in visible and UV range and the natural interpretation would be as bio-photons. The bio-photons detected outside body could represent sensory leakage. An interesting question is whether the IR Josephson frequencies could make possible some kind of IR vision.

To sum up, the basic criticism against the model is that the value of Weinberg angle must be by a factor of 1/10 smaller than the standard model value, and at this moment it is difficult to say anything about its value for nearly vacuum extremals.

A possible cure could be that the voltage is not same for different ions. This is possible since at microscopic level the Josephson junctions correspond to transmembrane proteins acting as channels and pumps. The membrane potential through receptor protein is different for color receptors. For this option one would have the correspondences

$Na^+ \leftrightarrow 2.19$ eV (R) and $eV = 86.8$ eV,
$Cl^- \leftrightarrow 2.32$ eV (G) and $eV = 65.8$ eV,
$K^+ \leftrightarrow 2.49$ eV (W) and $eV = 60.2$ eV,
$Ca^{++} \leftrightarrow 3.06$ eV (B) and $eV = 67.3$ meV.
For Na^+ the value of the membrane potential is suspiciously large.

It is interesting to look what happens when the model is generalized so that Josephson energy includes the difference of cyclotron energies at the two sides of the cell membrane and Weinberg angle has its standard model value.

1. Consider first *near to vacuum extremals*. In the formula for cyclotron frequencies in the effective magnetic field the factor Z/A in the formula of is replaced with

$$\frac{\frac{N-Z}{2p} + 2Z + q_{em}}{A} \quad,$$

which is not far from unity so that the cyclotron frequency would be near to that for proton for all ions. Also neutral atoms would experience classical and magnetic Z^0 fields. Cyclotron frequency would be almost particle independent so that cyclotron contribution gives an almost constant shift to the generalized Josephson energy. When the difference of cyclotron energies vanishes, the model reduces to that discussed above.

The weak independence of the cyclotron frequency on particle properties does not conform with the idea that EEG bands correspond to bosonic ions or Cooper pairs of fermionic ions.

2. For *far from vacuum extremals* the proportionality of cyclotron energy to h_{eff} and B_{end} allows easy reproduction the energies for which photon absorption is maximal if one allows the cyclotron energies to differ at the two sides of the membrane for sensory receptors.

A remark about decade later: The model just discussed neglects the fact that superconductivity requires that Cooper pairs of fermionic ions are present unless one assumes that the nuclei are bosonic counterparts of fermionic nuclei with same chemical properties - TGD inspired nuclear physics indeed predicts this kind of exotic nuclei [L3]. For Cooper pairs of Na^+, Cl^-, and K^+, $p = .23$ and $E_J = .04$ eV assignable to visual receptors the Josephson energies are doubled being $2.02, 2.80, 3.02$ eV. These energies could correspond to peak energies for visible photons. The assumption of ionic Cooper pairs is rather attractive since it would allow to avoid two questionable assumptions.

For electron the Josephson energy would be scaled by a factor $-1 + 1/2p$ to $E_J = 1.0859 \times eV_{rest}$ for $p = .2397$. For neutrino the energy would be given by $E_J = -0.0859 \times V_{rest}$: for $p = 1/4$ it would vanish by the vanishing of vectorial part of Z^0 charge. For proton the energy would be $E_J = (3 - 1/2p)V_{rest} = .914 \times V_{rest}$ and for neutron $E_J = V_{rest}/2p = 2.086 \times V_{rest}$.

9.6 Pollack's Findings About Fourth Phase Of Water And The Model Of Cell

The discovery of negatively charged exclusion zone formed in water bounded by gel phase has led Pollack to propose the notion of gel like fourth phase of water. In this article this notion is discussed in TGD framework. The proposal is that the fourth phase corresponds to negatively charged regions - exclusion zones - with size up to 100-200 microns generated when energy is fed into the water - say as radiation, in particular solar radiation. The stoichiometry of the exclusion zone is $H_{1.5}O$ and can be understood if every fourth proton is dark proton residing at the flux tubes of the magnetic body assignable to the exclusion zone and outside it.

This leads to a model for prebiotic cell as exclusion zone. Dark protons are proposed to form dark nuclei whose states can be grouped to groups corresponding to DNA, RNA, amino-acids, and tRNA and for which vertebrate genetic code is realized in a natural manner. The voltage associated with the system defines the analog of membrane potential, and serves as a source of metabolic energy as in the case of ordinary metabolism. The energy is liberated in a reverse phase transition in which dark protons transform to ordinary ones. Dark proton strings serve as analogs of basic biopolymers and one can imagine analog of bio-catalysis with enzymes replaced with their dark analogs. The recent discovery that metabolic cycles emerge spontaneously in absence of cell support this view.

One can find a biographical sketch [**?**] (`http://tinyurl.com/ycqtuchp`) giving a list of publications containing items related to the notions of exclusion zone and fourth phase of water discussed in the talk.

9.6.1 Pollack's Findings

I list below some basic experimental findings about fourth gel like phase of water made in the laboratory led by Gerald Pollack [L23].

1. In water bounded by a gel a layer of thickness up to 100-200 microns is formed. All impurities in this layer are taken outside the layer. This motivates the term "exclusion zone". The layer consists of layers of molecular thickness and in these layers the stoichiometry is $H_{1.5}O$. The layer is negatively charged. The outside region carries compensating positive charge. This kind of blobs are formed in living matter. Also in the splitting of water producing Brown's gas negatively charged regions are reported to emerge [H9, H1].

2. The process requires energy and irradiation by visible light or thermal radiation generates the layer. Even the radiation on skin can induce the phase transition. For instance, the blood flow in narrow surface veins requires metabolic energy and irradiation forces the blood to flow.

3. The layer can serve as a battery: Pollack talks about a form of free energy deriving basically from solar radiation. The particles in the layer are taken to the outside region, and this makes possible disinfection and separation of salt from sea water. One can even understand how clouds are formed and mysteries related to the surface tension of water as being due the presence of the layer formed by $H_{1.5}O$.

4. In the splitting of water producing Brown's gas [H9, H1] having a natural identification as Pollack's fourth phase of water the needed energy can come from several alternative sources: cavitation, electric field, etc...

9.6.2 Dark Nuclei And Pollack's Findings

While listening the lecture of Pollack I realized that a model for dark water in term of dark proton sequences is enough to explain the properties of the exotic water according to experiments done in the laboratory of Pollack. There is no need to assume sequences of half-dark water molecules containing one dark proton each.

Model for the formation of exclusion zones

The data about formation of exclusion zones allows to construct a more detailed model for what might happen in the formation of exclusion zones.

1. The dark proton sequences with dark proton having size of order atomic nucleus would reside at the flux tubes of dark magnetic field which is dipole like field in the first approximation and defines the magnetic body of the negatively charged water blob. This explains the charge separation if the flux tubes have length considerably longer than the size scale of the blob which is given by size of small cell. In the model inspired by Moray B. King's lectures charge separation is poorly understood.

2. An interesting question is whether the magnetic body is created by the electronic currents or whether it consists of flux tubes carrying monopole flux: in the latter case no currents would be needed. This is obviously purely TGD based possibility and due to the topology of CP_2.

3. This means that in the model inspired by the lectures of Moray B. King discussed above, one just replaces the sequences of partially dark water molecules with sequences of dark protons at the magnetic body of the $H1.5O$ blob. The model for the proto-variants of photosynthesis and metabolism remain as such. Also now genetic code would be realized [K53, L3].

4. The transfer of impurities from the exclusion zone could be interpreted as a transfer of them to the magnetic flux tubes outside the exclusion zone as dark matter.

These primitive forms of photosynthesis and metabolism form could be key parts of their higher level chemical variants. Photosynthesis by irradiation would induce a phase transition generating dark magnetic flux tubes (or transforming ordinary flux tubes to dark ones) and the dark proton sequences at them. Metabolism would mean burning of the resulting blobs of dark water to ordinary water leading to the loss of charge separation. This process would be analogous to the catabolism of organic polymers liberating energy. Also organic polymers in living matter carry their metabolic energy as dark proton sequences: the layer could also prevent their hydration. That these molecules are typically negatively charged would conform with the idea that dark protons at magnetic flux tubes carry the metabolic energy.

The liberation of energy would involve increase of the p-adic prime characterizing the flux tubes and reduction of Planck constant so that the thickness of the flux tubes remains the same but the intensity of the magnetic field is reduced. The cyclotron energy of dark protons is liberated in coherent fashion and in good approximation the frequencies of the radiation corresponds to multiplies of cyclotron frequency: this prediction is consistent with that in the original model for the findings of Blackman and others [J28].

The phase transition generating dark magnetic flux tubes containing dark proton sequences would be the fundamental step transforming inanimate matter to living matter and the fundamental purpose of metabolism would be to make this possible.

Minimal metabolic energy consumption and the value of membrane potential

This picture raises a question relating to the possible problems with physiological temperature.

1. The Josephson radiation generated by cell membrane has photon energies coming as multiples of ZeV, where V is membrane potential about .06 V and $Z = 2$ is the charge of electron Cooper pair. This gives $E = .12$ eV.

2. There is a danger that thermal radiation masks Josephson radiation. The energy for photons at the maximum of the energy density of blackbody radiation as function of frequency is given as the maximum of function $x^3/(e^x - 1)$, $x = E/T$ given by $e^{-x} + x/3 - 1 = 0$. The maximum is given approximately by $x = 3$ and thus $E_{max} \simeq 3T$ (in units $c = 1, k_B = 1$). At physiological temperature $T = 310$ K (37 C) this gives .1 eV, which is slightly below Josephson energy: living matter seems to have minimized the value of Josephson energy - presumably to minimize metabolic costs. Note however that for the thermal energy density as function of *wavelength* the maximum is at $E \simeq 5T$ corresponding to 1.55 eV which is larger than Josephson energy. The situation is clearly critical.

3. One can ask whether also a local reduction of temperature around cell membrane in the fourth phase of water is needed.

   "Electric expansion" of water giving rise to charge separation and presumably creating fourth phase of water is reported to occur [H9, H1].

   (b) Could the electric expansion/phase transition to dark phase be adiabatic involving therefore no heat transfer between the expanding water and environment? If so, it would transform some thermal energy of expanding water to work and reduce its temperature. The formula for the adiabatic expansion of ideal gas with f degrees of freedom for particle ($f = 3$ if there are no other than translational degrees of freedom) is $(T/T_0) = (V/V_0)^{-\gamma}$, $\gamma = (f + 2)/f$. This gives some idea about how large reduction of temperature might be involved. If p-adic scaling for water volume by a power of two takes place, the reduction of temperature can be quite large and it does not look realistic.

   (c) The electric expansion of water need not however involve the increase of Planck constant for water volume. Only the Planck constant for flux tubes must increase and would allow the formation of dark proton sequences and the generation of cyclotron Bose-Einstein condensates or their dark analog in which fermions (electrons in particular) effectively behave as bosons (the anti-symmetrization of wave function would occur in dark degrees of freedom corresponding to multi-sheeted covering formed in the process).

9.6.3 Fourth Phase Of Water And Pre-Biotic Life In TGD Universe

Metabolism and fourth phase of water

If the fourth phase of water defines pre-biotic life form then the phase transition generating fourth phase of water and its reversal are expected to be fundamental elements of the ordinary metabolism, which would have developed from the pre-biotic metabolism. The following arguments conforms with this expectation.

1. Cell interiors, in particular the interior of the inner mitochondrial membrane are negatively charged as the regions formed in Pollack's experiments. Furthermore, the citric acid cycle, (`http://tinyurl.com/y8ubjgnc`), which forms the basic element of both photosynthesis (`http://tinyurl.com/yauwzkho`) and cellular respiration `http://tinyurl.com/ybeefxmb`, involves electron transport chain (`http://tinyurl.com/yat3m4vk`) in which electron loses gradually its energy via production of NADP and proton at given step. Protons are pumped to the other side of the membrane and generates proton gradient serving as metabolic energy storage just like battery. The interpretation for the electron transport chain in terms of Pollack's experiment would be in terms of generation of dark protons at the other side of the membrane.

2. When ATP is generated from ADP three protons per ATP flow back along the channel formed by the ATP synthase molecule (`http://tinyurl.com/yd5ndcyk`) (perhaps Josephson junction) and rotate the shaft of a "motor" acting as a catalyst generating three ATP molecules per turn by phosphorylating ADP. The TGD based interpretation is that dark protons are transformed back to ordinary ones and possible negentropic entanglement is lost.

3. ATP is generated also in glycolysis (`http://tinyurl.com/ybzgdgve`), which is ten-step process occurring in cytosol so that membrane like structure need not be involved. Glycolysis involves also generation of two NADH molecules and protons. An open question (to me) is whether the protons are transferred through an endoplasmic reticulum or from a region of ordered water (fourth phase of water) to its exterior so that it would contribute to potential gradient and could go to magnetic flux tubes as dark proton. This would be natural since glycolysis is realized for nearly all organisms and electron transport chain is preceded by glycolysis and uses as input the output of glycolysis (two pyruvate molecules (`http://tinyurl.com/y8v7aq9s`)).

4. Biopolymers - including DNA and ATP - are typically negatively charged. They could thus be surrounded by fourth phase of water and neutralizing protons would reside at the magnetic bodies. This kind of picture would conform with the idea that the fourth phase (as also magnetic body) is fractal like. In phosphorylation the metabolic energy stored to a potential difference is transferred to shorter length scales (from cell membrane scale to molecular scale).

In glycolysis (`http://tinyurl.com/ybzgdgve`) the net reaction $C_6H_{12}O_6+6O_2 \rightarrow 6CO_2(g)+6H_2O(l)+heat$ takes place. The Gibbs free energy change is $\Delta G = -2880$ kJ per mole of $C_6H_{12}O_6$ and is negative so that the process takes place spontaneously. Single glucose molecule is theoretized to produce $N = 38$ ATP molecules in optimal situation but there are various energy losses involved and the actual value is estimated to be 29-30. From $Joule = 6.84 \times 10^{18}$ eV and $mol = 6.02 \times 10^{23}$ and for $N = 38$ one would obtain the energy yield.86 eV per single ATP. The nominal value that I have used.5 eV. This is roughly 5 to 8 times higher than $E = ZeV, Z = 2$, which varies in the range.1-.16 eV so that the metabolic energy gain cannot be solely due to the electrostatic energy which would actually give only a small contribution.

In the thermodynamical approach to metabolism the additional contribution would be due to the difference of the chemical potential μ for cell exterior and interior, which is added to the membrane potential as effective potential energy. The discrepancy is however rather large and this forces the question the feasibility of the model. This forces to reconsider the model of osmosis in the light of Pollack's findings.

Pollack's findings in relation to osmosis and model for cell membrane and EEG

Osmosis (`http://tinyurl.com/yc5dbtzv`) has remained to me poorly understood phenomenon. Osmosis means that solvent molecules move through a semipermeable membrane to another side of the membrane if the concentration of solute is higher at that side. Solute can be water or more general liquid, supercritical liquid, and even gas.

Osmosis is not diffusion: it can occur also towards a higher concentration of water. Water molecules are not attracted by solute molecules. A force is required and the Wikipedia explanation is that solute molecules approaching pores from outside experience repulsion and gain momentum which is transferred to the water molecules.

The findings of Pollack inspire the question whether the formation of exclusion zone could relate to osmosis and be understood in terms of the fourth phase of water using genuine quantal description.

In the thermodynamical model for ionic concentrations one adds to the membrane resting potential a contribution from the difference of chemical potentials μ_i at the two sides of the membrane. Chemical potentials for the ions parametrize the properties of the cell membrane reducing basically to the properties of the channels and pumps (free diffusion and membrane potential do not entirely determine the outcome).

If the transfer of ions - now protons - through cell membrane is quantal process and through Josephson junctions defined by transmembrane proteins, then the thermodynamical model can at best be a phenomenological parameterization of the situation. One should find the quantum counterpart of thermodynamical description, and here the identification of quantum TGD as square root of thermodynamics in Zero Energy Ontology (ZEO) suggests itself. In this approach thermodynamical distributions are replaced by probability amplitudes at single particle level such that their moduli squared give Boltzmann weights.

1. Simplest Josephson junction model for cell membrane

The first guess is that quantum description is achieved by a generalization of the Josephson junction model allowing different values of Planck constant at magnetic flux tubes carrying dark matter.

1. Josephson junctions correspond microscopically to transmembrane proteins defining channels and pumps. In rougher description entire cell membrane is described as Josephson junction.

2. The magnetic field strength at flux tube can differ at the opposite side of the membrane and even the values of h_{eff} could in principle be different. The earlier modelling attempts

suggest that $h_{eff}/h = n = 2^k A$, where A is the atomic weight of ion, is a starting assumption deserving testing. This would mean that each ion resides at its own flux tubes.

The phase transitions changing the value of h_{eff} could induce ionic flows through cell membrane, say that occurring during nerve pulse since the energy difference defining the ratio of square roots of Boltzmann weights at the two sides of the membrane would change. Also the change of the local value of the magnetic field could do the same.

Consider first the simplest model taking into account only membrane potential.

1. The simplest model for Josephson junction defined by the transmembrane protein is as a two state system (Ψ_1, Ψ_2) obeying Schrödinger equation.

$$i\hbar_1 \frac{\partial \Psi_1}{\partial t} = ZeV\Psi_1 + k_1\Psi_2 \ ,$$

$$i\hbar_2 \frac{\partial \Psi_2}{\partial t} = k_2\Psi_2 \ .$$

One can use the decomposition $\Psi_i = R_i exp(i\Phi(t))$ to express the equations in a more concrete form. The basic condition is that the total probability defined as sum of moduli squared equals to one: $R_1^2 + R_2^2 = 1$. This is guaranteed if the hermiticity condition $k_1/\hbar_1 = \overline{k_2}\hbar_2$ holds true. Equations reduce to those for an ordinary Josephson junction except that the frequency for the oscillating Josephson current is scaled down by $1/h_{eff}$.

2. One can solve for R_2 assuming $\Phi_1 = eVt/\hbar_{eff}$. This gives

$$R_2(t) = sin(\Phi_0) + \frac{k_1}{\hbar_1} sin(\frac{eVt}{\hbar_1}) \ .$$

R_2 oscillates around $sin(\Phi_0)$ and the concentration difference is coded by $\Phi 0$ taking the role of chemical potential as a phenomenological parameter.

3. The counterparts of Boltzmann weights would be apart from a phase factor square roots of ordinary Boltzmann weights defined by the exponent of Coulomb energy:

$$R = sin(\phi_0) = exp(\frac{ZeV(t)}{2T}) \ .$$

Temperature would appear as a parameter in single particle wave function and the interpretation would be that thermodynamical distribution is replaced by its square root in quantum theory. In ZEO density matrix is replaced by its hermitian square root multiplied by density matrix.

2. The counterpart of chemical potential in TGD description

This model is not as such physically realistic since the counterpart of chemical potential is lacking. The most straightforward generalization of the thermodynamical model is obtained by the addition of an ion dependent chemical potential term to the membrane potential: $ZeV \rightarrow ZeV + \mu_I$. This would however require a concrete physical interpretation.

1. The most obvious possibility is that also the chemical potential actually correspond to an interaction energy - most naturally the cyclotron energy $E_c = \hbar_{eff} ZeB_{end}/m$ of ion - in this case proton - at the magnetic flux tube. Cyclotron energy is proportional to h_{eff} and can be rather large as assumed in the model for the effects of ELF em fields on brain.

2. This model would predict the dependence of the effective chemical potential on the mass and charge of ion for a fixed value of on h_{eff} and B_{end}. The scales of ionic chemical potential and ion concentrations would also depend on value of h_{eff}.

3. The model would provide a different interpretation for the energy scale of bio-photons, which is in visible range rather than infrared as suggested by the value of membrane potential.

   The earlier proposal [K50] was that cell membrane can be in near vacuum extremal configuration in which classical Z^0 field contributes to the membrane potential and gives a large contribution for ions. The problematic aspect of the model was the necessity to assume Weinberg angle in this phase to have much smaller value than usually. This difficulty could be perhaps avoided by noticing that the membrane potentials can differ for color receptors so that the earlier assignment of specific ions to color receptors could make sense for ordinary value of Weingerg angle. Second problem is that for proton the Z^0 contribution is negligible in good approximation so that this model does not explain the high value of the metabolic energy currency.

4. The simplest model the communications to magnetic body rely on Josephson radiation whose fundamental frequency f_J is at resonance identical with the cyclotron frequency $f_c(MB)$ at particular part of the flux tube of the magnetic body: $(f_c(MB) = f_J$. $f_c(MB)$ corresponds to EEG frequency in the case of brain and biophotons are produced from dark EEG photons as ordinary photons in phase transition reducing $h_{eff} = n \times h$ to h.

   In the modified model the sum $f_c + f_{J,n}$ ($f_{J,n} = E_J/n \times h$) of h_{eff}-independent cyclotron frequency and Josephson frequency proportional to $1/h_{eff}$ equals to cyclotron frequency $f_c(MB)$ at "personal" magnetic body varying slowly along the flux tube: $f_c + f_{J,n} = f_c(MB)$. If also the variation of f_J assignable to the action potential is included, the total variation of membrane potential gives rise to a frequency band with width roughly

   $$\frac{\Delta f}{f} \simeq \frac{2f_{J,n}}{f_c + f_{J,n}} = \frac{2f_{J,1}}{nf_c + f_{J,1}} \quad .$$

   If dark photons correspond to biophotons the energy is of cyclotron photon is in visible and UV range one has $nf_c = E_{bio}$ and

   $$\frac{\Delta f}{f} \simeq \frac{2ZeV}{E_{bio} + ZeV} \quad .$$

   The prediction is scale invariant and same for all ions and also electron unless E_{bio} depends on ion. For $eV = .05$ eV, $Z = 1$, and $E_{bio} = 2$ eV ($f \simeq 5 \times 10^{14}$ Hz) one has $\Delta f/f \sim .1$ giving 10 per cent width for EEG bands assumed in the simpler model.

   If this vision is on the correct track, the fundamental description of osmosis would be in terms of a phase transition to the fourth phase of water involving generation of dark matter transferred to the magnetic flux tubes. For instance, the swelling of cell by an in-flow of water in presence of higher concentration inside cell could be interpreted as a phase transition extending exclusion zone as a process accompanied by a phase transition increasing the value of h_{eff} so that the lengths of the flux tube portions inside the cell increase and the size of the exclusion zone increases. In general case the phase transitions changing h_{eff} and B_{end} by power of two factor are possible. This description should bring magnetic body as part of bio-chemistry and allow understanding of both equilibriumion distributions, generation of nerve pulse, and basic metabolic processes leading to the generation of ATP.

   One can also model sensory receptors and try to understand the maximal sensitivity of color receptors to specific wavelengths in this framework. The new degrees of freedom make this task easy if one is only interested in reproducing these frequencies. More difficult challenge is to understand the color receptors from the first principles. It is also possible to combine the new view with the assumption that sensory receptor cells are near to vacuum extremals. This would add a cyclotron contribution to the generalized Josephson frequency depending only weakly on particle and being non-vanishing also for em neutral particles.

Why would charge separation generate large h_{eff}?

The basic question is whether and how the separation of electron and proton charges generates large h_{eff}? A possible mechanism emerged from a model [K109] explaining anomalously large

gravimagnetic effect claimed by Tajmar *et al* [E7, E9] to explain the well-established anomaly related to the mass of Cooper pairs in rotating super-conduction. The mass is too large by fraction of order 10^{-4} and the proposal is that gravimagnetism changes slightly the effective Thomson magnetic field associated with the rotating super-conductor leading to wrong value of Cooper pairs mass when only ordinary Thomson field is assumed to be present. The needed gravimagnetic field is however gigantic: 28 orders larger than that predicted by GRT. Gravimagnetic field is proportional h_{eff}^2 in TGD and if one uses h_{gr} for electron-Earth system one obtains correct order of magnitude.

Nottale's finding that planetary orbits seem to correspond to Bohr orbits in gravitational potential with gigantic value of gravitational Planck constant is the basic input leading to the model of gravimagnetic anomaly.

1. By Equivalence Principle h_{gr} has the general form $h_{gr} = GMm/v_0$, where M and m are the interacting masses and v_0 is a parameter with dimensions of velocity. For 4 inner planets one has $v_0/c \simeq 2^{-11}$.

2. The notion of h_{gr} generalizes to that for other interactions. For instance, in electromagnetic case the formation of strong em fields implying charge separation leads to systems in which $h_{em} = Z_1 Z_2 e^2/v_0$ is large. Pollack's exclusion zone and its complement define this kind of systems and is identified as prebiotic life form.

3. Since the natural expansion parameter of perturbative expansion is the $g^2/4\pi\hbar$, one can say that transition to dark matter phase make the situation perturbative. Mother Nature is theoretician friendly.

h_{em} might be large in the exclusion zones (EZ) appearing in the water bounded by gel and their variants could play central role in living matter.

1. EZ carries very large negative charge with positive charge outside the exclusion zone.

2. TGD interpretation is in terms of $H_{1.5}O$ phase of water formed when every 4: th proton is transferred to magnetic body as dark particle with large value of h_{eff}. The proposal is that primitive life form is in question.

3. The pair formed by EZ and its complement could have large value of $h_{eff} = h_{em} = Z^2 e^2/v_0$.

4. The velocity parameter v_0 should correspond to some natural rotation velocity. What comes in mind is that complement refers to Earth and v_0 is the rotation velocity at the surface of Earth. The prediction for h_{eff} would be of order $h_{em}/h = 4\pi\alpha Z^2 \times .645 \times 10^6 \simeq 5.9 \times 10^4 Z^2$.

5. Cell membrane involves also large charge separation due to very strong electric field over the cell membrane. Also now dark phases with large h_{em} or h_{gr} could be formed.

I have proposed that metabolic machinery generates large h_{eff} phase somehow. $h_{eff} = h_{em}$ hypothesis allows to develop this hypothesis in more detail.

1. I have speculated earlier [K58] that the rotating shaft of a molecular motor associated with ATP synthase plays a key role in generating dark matter phase. What comes in mind is that charge separation takes place associating exclusion zone with the shaft and the rotational velocity v_0 of the shaft appears in the formula for h_{em}. Of course, some numerical constant not far from unity could be present. The electric field over the mitochondrial membrane generates charge separation. One can imagine several identifications for the product of charges. The charge Z associated with the complement would be naturally associated with single dark flux tube containing dark nucleon consisting of dark protons. For instance, the charge associated with the exclusion zone could be the charge of the electronic Cooper pair giving $h_{em} = 2e \times Z/v_0$.

2. The value of v_0/c is expected to be of order 10^{-14} from the angular rotation rate of ADP synthase about few hundred revolutions per second. The order of magnitude for h_{em} could be same as for h_{gr} associated with Earth-particle system.

$h_{eff}(ATPsynthase) = h_{gr}(2e, Earth)$ would make possible reconnection of electromagnetic flux tubes with gravimagnetic flux tubes [K90].

Which came first: metabolism or cell membrane?

One of the basic questions of biology is whether metabolism preceded basic biopolymers or vice versa. RNA world scenario assumes that RNA and perhaps also genetic code was first.

1. The above view suggests that both approaches are correct to some degree in TGD Universe. Both metabolism and genetic code realized in terms of dark proton sequences would have emerged simultaneously and bio-chemistry self-organized around them. Dark proton sequences defining analogs of amino-acid sequences could have defined analogs of protein catalysts and played a key role in the evolution of the metabolic pathways from the primitive pathways involving only the phase transition between ordinary water and fourth phase of water.

2. There is very interesting article (see `http://tinyurl.com/ycdhd4fd`) [?]eporting that complex metabolic pathways are generated spontaneously in laboratory environments mimicking hot thermal vents. Glycolysis and pentose phosphate pathway were detected. The proposal is that these pathways are catalyzed by metals rather than protein catalysts.

3. In standard biology these findings would mean that these metabolic pathways emerged before basic biopolymers and that genetic code is not needed to code for the metabolic pathways during this period. In TGD framework dark genetic code [K53, L3] would be there, and could code for the dark pathways. Dark proton strings in one-one correspondence with the amino-acid sequences could be responsible for catalysts appearing in the pathways. Only later these catalysts would have transformed to their chemical counterparts and might be accompanied by their dark templates. One cannot even exclude the possibility that the chemical realization of the DNA-amino-acid correspondence involves its dark analog in an essential manner.

9.6.4   Could Pollack effect make cell membrane a self-loading battery?

The so called Clarendon dry pile is 175 years old battery still working. The current is very weak (nano Ampere) but the working of the battery is claimed to be not well-understood. The TGD inspired model for cold fusion leads to the proposal that Pollack effect is part of electrolysis. This inspires the idea that Pollack effect and possibly also the associated cold fusion could make Clarendon dry pile a self-loading battery. Cell membrane can be regarded as the analog of self-loading battery, and in TGD framework also as a generalised Josephson junction. Hence one can ask whether also cell membrane could be seen as a self-loading battery utilizing Pollack's mechanism. This would also allow to understand why hyperpolarization stabilizes the membrane potential and why depolarization generates nerve pulse.

Clarendon pile: 175 years old battery still working

Elemer Rosinger had a Facebook link to an article telling about Clarendon dry pile, a very long-lived battery providing energy for an electric clock (see `http://tinyurl.com/zeut69y`, `http://tinyurl.com/jhrww2a`, and `http://tinyurl.com/gvbrhra`). This clock known also as Oxford bell has been ringing for 175 years now and the article suggests that the longevity of the battery is not really understood. The bell is not actually ringing so loud that human ear could hear it but one can see the motion of the small metal sphere between the oppositely charged electrodes of the battery in the video.

The function principle of the clock is simple. The gravitational field of earth is also present. When the sphere touches the negative electrode, it receives a bunch of electrons and gives the bunch away as it touches positive electrode so that a current consisting of these bunches is running between electrons. The average current during the oscillation period of 2 seconds is nanoampere so that nanocoulomb of charge is transferred during each period (Coulomb corresponds to a 6.242×10^{18} elementary charges (electrons)).

The dry pile was discovered by priest and physicist Giuseppe Zamboni at 1812 (see `http://tinyurl.com/jkvtj6f`). The pile consists of 2,000 pairs of pairs of discs of tin foil glued to paper impregnated with Zinc sulphate and coated on the other side with manganese dioxide: 2,000 thin batteries in series. The operation of battery gradually leads to the oxidation of Zinc and the loss

of magnase dioxide but the process takes place very slowly. One might actually wonder whether it takes place too slowly so that some other source of energy than the electrostatic energy of the battery would be keep the clock running. Karpen pile is analogous battery discover by Vasily Karpen (see `http://tinyurl.com/jpzcs32`). It has now worked for 50 years.

Cold fusion is associated with electrolysis. Could the functioning of this mystery clock involve cold fusion taken seriously even by American Physical Society thanks to the work of the group of prof. Holmlid. Electrolytes have of course been "understood" for aeons. Ionization leads to charge separation and current flows in the resulting voltage. With a feeling of deep shame I must confess that I cannot understand how the ionization is possible in standard physics. This of course might be just my immense stupidity - every second year physics student would immediately tell that this is "trivial" - so trivial that he would not even bother to explain why. The electric field between the electrodes is immensely weak in the scale of molecules. How can it induce the ionisation? Could ordinary electrolytes involve new physics involving cold fusion liberating energy? These are the questions which pop up in my stupid mind. Stubborn as I am in my delusions, I have proposed what this new physics might be with inspiration coming from strange experimental findings of Gerald Pollack, cold fusion, and my own view about dark matter has phases of ordinary matter with non-standard value $h_{eff} = n \times h$ of Planck constant. Continuing with my weird delusions I dare ask: Could cold fusion provide the energy for the "miracle" battery?

What batteries are?

To understand what might be involved one must first learn some basic concepts. I am trying to do the same.

1. Battery (see `http://tinyurl.com/8xqsnab`) consistes of two distinct electrochemical cells (see `http://tinyurl.com/jq8ljmo`). Cell consists of electrode and electrolyte. The electrodes are called anode and catode. By definition electron current along external wire flows to catode and leaves anode.

2. There are also ionic currents flowing inside the battery. In absence of the ionic currents the electrodes of the battery lose their charge. In the loading the electrodes get their charges. In the ideal situation the ionic current is same as electron current and the battery does not lose its charging. Chemical reactions are however taking place near and at the electrodes and in their reversals take place during charging. Chemical changes are not completely reversible so that the lifetime of the battery is finite.

   The ionic current can be rather complex: the carriers of the positive charge from anode can even change during the charge transfer: what matters that negative charge from catode is transferred to anode in some manner and this charge logistics can involve several steps. Near the catode the currents of positive ions (cations) and electrons from the anode combine to form neutral molecules. The negative current carriers from catode to the anode are called anions.

3. The charge of the clectrochemical cell is in the electrolyte near the surface of the electrode rather than inside it as one might first think and the chemical processes involve neutralization of ion and the transfer of neutral outcome to or from the electrode.

4. Catode - or better, the electrochemical cell containing the catode - can have both signs of charge. For positive charge one has a battery liberating energy as the electron current connecting the negative and positive poles goes through the load, such as LED. For negative charge current flows only if there is external energy feed: this is loading of the battery. External voltage source and thus energy is needed to drive the negative charges and positive charges to the electrodes. The chemical reactions involved can be rather complex and proceed in reverse direction during the loading process. Travel phone battery is a familiar example.

   During charging the roles of the anode and catode are changed: understanding this helps considerably.

Could dark cold fusion make possible self-loading batteries?

Could cold fusion help to understand why the Clarendon dry pile is so long lived?

1. The battery is series of very many simpler batteries. The mechanism should reduce to the level of single building brick. This is assumed in the following.

2. The charge of the battery tends to be reduced unless the ionic and electronic currents are identical. Also chemical changes occur. The mechanism involved should oppose the reduction of the charging by creating positive charge to the catode and negative charge to the anode or induce additional voltage between the electrodes of the battery inducing its loading. The energy feed involved might also change the direction of the basic chemical reactions as in the ordinary loading by raising the temperature at catode or anode.

3. Could be formation of Pollack's exclusion zones (EZs) in the elecrolytic cell containing the anode help to achieve this? EZs carry a high electronic charge. According to TGD based model protons are transformed to dark protons at magnetic flux tubes. If the positive dark charge at the flux tubes is transferred to the electrolytic cell containing catode and transformed to ordinary charge, it would increase the positive charge of the catode. The effect would be analogous to the loading of battery. The energy liberated in the process would compensate for the loss of charge energy due to electronic and ionic currents.

4. In the ordinary loading of the battery the voltage between batteries induces the reversal of the chemical processes occurring in the battery. This is due to the external energy feed. Could the energy feed from dark cold fusion induce similar effects now? For instance, could the energy liberated at the catode as positively charged dark nuclei transform to ordinary ones raise the temperature and in this manner feed the energy needed to change the direction of the chemical reactions.

Cell membrane as self-loading battery and how nerve pulse is generated?

This model might have an interesting application to the physics of cell membrane.

1. Cell membrane consisting of two lipid layers defines the analog of a battery. Cell interior plus inner lipid layer (anode) and cell exterior plus outer lipid layer (catode) are analogs of electrolyte cells.

   What has been troubling me for two decades is how this battery manages to load itself. Metabolic energy is certainly needed and ADP-ATP mechanism is essential element. I do not however understand how the membrane manages to keep its voltage.

   Second mystery is why it is hyperpolarization rather than polarization, which tends to stabilize the membrane potential in the sense that the probability for the spontaneous generation of nerve pulse is reduced. Neither do I understand why depolarization (reduction of the membrane voltage) leads to a generation of nerve pulse involving rapid change of the sign of the membrane voltage and the flow of various ionic currents between the interior and exterior of the cell.

2. In the TGD inspired model for nerve pulse cell interior and cell exterior or at least their regions near to lipid layers are regarded as super-conductors forming a generalized Josephson junction. For the ordinary Josephson junction the Coulombic energy due to the membrane voltage defines Josephson energy. Now Josephson energy is replaced by the ordinary Josephson energy plus the difference of cyclotron energies of the ion at the two sides of the membrane. Also ordinary Josephson radiation can be generated. The Josephson currents are assumed to run along magnetic flux tubes connecting cell interior and exterior. This assumption receives support from the strange finding that the small quantal currents associated with the membrane remain essentially the same when the membrane is replaced with polymer membrane.

3. The model for Clarendon dry pile suggests an explanation for the self-loading ability. The electrolytic cell containing the anode corresponds to the negatively charged cell interior,

where Pollack's EZs would be generated spontaneously and the feed of protonic charge to the outside of the membrane would be along flux tubes as dark protons to minimize dissipation. Also ions would flow along them. The dark protons driven to the outside of the membrane transform to ordinary ones or remain dark and flow spontaneously back and provide the energy needed to add phosphate to ADP to get ATP.

4. The system could be quantum critical in the sense that a small reduction of the membrane potential induces nerve pulse. Why the ability to generate Pollack's EZs in the interior would be lost for a few milliseconds during nerve pulse? The hint comes from the fact that Pollack's EZs can be generated by feeding infrared radiation to a water bounded by gel. Also the ordinary Josephson radiation generated by cell membrane Josephson junction has energy in infrared range!

   Could the ordinary Josephson radiation generate EZs by inducing the ionization of almost ionized hydrogen bonded pairs of water molecules. The hydrogen bonded pairs must be very near to the ionization energy so that ordinary Josephson energy of about .06 eV assignable to the membrane voltage is enough to induce the ionization followed by the formation of $H_{3/2}O$. The resulting EZ would consist of layers with the effective stoichiometry $H_{3/2}O$.

   As the membrane voltage is reduced, Josephson energy would not be anymore enough to induce the ionization of hydrogen bonded pair of water molecules, EZs are not generated, and the battery voltage is rapidly reduced: nerve pulse is created. In the case of hyperpolarization the energy excees the energy needed for ionization and the situation becomes more stable.

5. This model could also allow to understand the effect of anesthetes [K88] [L31]. Anesthetes could basically induce hyperpolarization so that Josephson photons would continually generate Pollack's EZ:s and creating of dark particles at the magnetic flux tubes. This need not mean that consciousness is lost at the cell level. Only sensory and motor actions are prevented because nerve pulses are not possible. This prevents formation of sensory and motor mental images at our level of hierarchy.

   Meyer-Overton correlation states that the effectiveness of the anesthete correlates with its solubility to the lipid membrane. This is the case if the presence of anesthete in the membrane induces hyperpolarization so that the energies of the photons of Josephson radiation would be higher than needed for the generation of EZs accompanied by magnetic flux tubes along which ionic Josephson currents would flow between cell interior and exterior. For these quantal currents evidence exists [K92]. In the case of battery these dark ions would flow from the cell containing anode to that containing catode. For depolarization the energy of Josephson photons would be too low to allow the kicking off protons from hydrogen bonded pairs of water molecules so that EZs would not be created and self-loading would stop and nerve pulse would be generated.

9.7 Could Photosensitive Emulsions Make Dark Matter Visible?

The article "Possible detection of tachyon monopoles in photographic emulsions" by Keith Fredericks [H8] describes in detail (`http://tinyurl.com/ybjk94f9`) very interesting observations by him and also by many other researchers about strange tracks in photographic emulsions induced by various (probably) non-biological mechanisms and also by the exposure to human hands (touching by fingertips) as in the experiments of Fredericks. That the photographic emulsion itself consists of organic matter (say gelatin) might be of significance.

9.7.1 The Findings

The tracks have width between 5 μm-110 μm (horizontal) and 5 μm-460 μm (vertical). Even tracks of length up to at least 6.9 cm have been found. Tracks begin at some point and end abruptly. A given track can have both random and almost linear portions, regular periodic structures (figs 11 and 12), tracks can appear in swarms (**Fig.** 24), bundles (**Fig.** 25), and correlated pairs (**Fig.**

16), tracks can also split and recombine (**Fig. 32**) (here and below "**Fig.**" refers to a figure of the article at `http://tinyurl.com/ybjk94f9`).

Tracks differ from tracks of known particles: the constant width of track implies that electrons are not in question. No delta rays (fast electrons caused by secondary ionization appearing as branches in the track) characteristic for ions are present. Unlike alpha particle tracks the tracks are not straight. In magnetic fields tracks have parabolic portions whereas ordinary charged particle move along spiral. The magnetic field needed to cause spiral structure for baryons should be by two orders of magnitude higher than in the experiments.

For particle physicist all these features - for instance constant width - strongly suggest pre-existing structures becoming visible for some reason. The pre-existing structure could of course correspond to something completely standard structures present in the emulsion. If one is ready to accept that biology involves new physics, it could be something more interesting.

Also evidence for cold fusion is reported by the group of Urutskoev [H4]. There is evidence for cold fusion in living matter [C1, C12]: the fact that the emulsion contains gelatin might relate to this. In [L3] a dark matter based mechanism of cold fusion allowing protons to overcome the Coulomb wall is discussed. Either dark protons or dark nuclei with much larger quantum size than usually would make this possible and protons could end up to the dark nuclei along dark flux tubes. In TGD inspired biology dark protons (large h_{eff}) with scaled up Compton length of order atomic size are proposed to play key role since their states allow interpretation in terms of vertebrate genetic code [L3, K30].

9.7.2   The Importance Of Belief System

These structures could be something quite standard or not. This readiness to consider non-standard explanations depends on belief system.

1. In the belief system of standard physics these pre-existing structures would be organic material consisting of ordinary matter so that no new physics is involved. Probably it is easy to kill this hypothesis. If this can be done, the situation becomes really interesting.

2. In my own belief system they *could* correspond to dark matter structures made visible by some mechanism. The presence of human hands could induce this phenomenon in the experiments of Fredericks. If so we might be already considering remote interactions involving dark photons and magnetic flux tubes, whose images "tracks" would be.

3. The first guess is that these structures are in the emulsion. This need not be the case! They could be structures outside- say in human hands - sending dark photon beam absorbed by the small photosensitive crystals in the emulsion. A photograph of dark matter (say in the hands of sender) would be formed! One possibility is that tracks represent a photograph of the dark matter at the flux tubes of the magnetic body of the emulsion. This would be a variant for what Gariaev perhaps managed to achieve with camera: taking a photo of dark matter [K1] !

4. Unfortunately belief system becomes important also in second manner. The reductionistic belief system tells that the tracks must be something trivial. There cannot be new physics in scale of cell as we have read in text books. Therefore these tracks are not studied by professionals who could very easily find whether there is something really interesting involved.

Dark matter in TGD based belief system corresponds to a hierarchy of phases of ordinary matter with an effective value h_{eff} of Planck constant coming as integer multiple of ordinary Planck constant. This makes possible macroscopic quantum phases consisting of dark matter. The flux tubes could carry magnetic monopole flux but the magnetic charge would be topological (made possible by the non-trivial second homology of CP_2 factor of the 8-D embedding space containing space-times as surfaces) rather than Dirac type magnetic charge.

The TGD inspired identification of tracks could be as images of magnetic flux tubes or bundles of them containing dark matter defining one of the basic new physics elements in TGD based quantum biology. One can imagine two options for the identification of the tracks as "tracks".

1. The primary structures are in the photo-sensive emulsion.

2. The structures in photograph are photographs of dark matter in external world, say structures in human hands or human body or of dark matter at some magnetic body, say at the flux tubes of the magnetic body of the emulsion.

The fact that the tracks have been observed in experimental arrangements not involving exposure to human hands, indeed suggests that tracks represent photographs about parts of the magnetic body assignable to the emulsion. For this option the external source would serve only as the source of possibly dark photons.

This would imply a close analogy with the experiments of Peter Gariaev's group interpreted in TGD framework as photographing of the magnetic body of DNA sample [K1]. Also here one has an external source of light: the light would be transformed to dark photons in DNA sample, scatter from the dark charged particles at the flux tubes of the magnetic body of DNA sample, and return back transforming to ordinary light and generating the image in the photosensitive emulsion.

9.7.3   Why Not Tachyonic Monopoles?

The identification of the tracks as orbits of particles proposed by author and also by other experimentalists is to my opinion problematic for the reasons which I have already explained. The article of Fredericks lists further details which do not conform with the particle interpretation. A further proposal is that the particles are tachyonic magnetic monopoles. One motivation for the monopole hypothesis is the (unsuccessful) attempt to explain the parabolic shape of the tracks in external magnetic field.

To my view the interpretation as a tachyonic monopole - a notion introduced by Recami and Mignani [H10] (`http://tinyurl.com/yajz68tt`) - adopted in the article is theoretically problematic. Of course, if the tracks are actually pre-existing structures made visible by some mechanism, there is no need to postulate super-luminal propagation. To see the problem, one can start from a general formula relating energy, momentum and mass. One has

$$E^2 = p^2 + m^2 \ . \tag{9.7.1}$$

When m is imaginary as for tachyon so that one can write $m = iM$, one obtains

$$E^2 = p^2 - M^2 \ . \tag{9.7.2}$$

If E and p are assumed to be real as is done usually the condition $E \geq 0$ and more generally the reality of E gives $p \geq M$. Tachyon cannot therefore be at rest and one cannot assign to it kinetic energy since tachyon at rest would have imaginary energy.

This has two implications.

1. The identification as tachyon and the conclusion $p \ll M$ from experiments (see figure 34 for the relation between E, p and m in various cases) is not consistent with $p \geq M$.

2. Recami and Mignani assign a kinetic energy to tachyon (formula 14). Unfortunately, this formula does not make sense if one accepts that E and p are real since one cannot assign to tachyon kinetic energy: the analogy of kinetic energy would be "kinetic momentum" defined as the difference of the actual momentum and minimal momentum $p = M$ ($p_{kin} = \sqrt{E^2 + M^2} - M \simeq E - M - M^2/2E$). As Fredericks notices, the behavior is not actually consistent with a motion of magnetic monopole in magnetic field. Parabolic orbits are in plane orthogonal to magnetic field rather than containing its direction vector (`http://tinyurl.com/ybjk94f9`)!

9.7.4   Interpretation As Dark Matter Structures Becoming Visible In Presence Of Living Matter

As such the observations are extremely interesting. I cannot however believe that the tracks represent particles. To my opinion tachyonic monopole interpretation fails because it does not make sense to talk about kinetic energy of tachyon.

To me the complex structures of tracks very strongly suggest pre-existing structures becoming visible for some reason. Looking the shape of tracks brings to my mind linear structure such as protein molecules. They contain regular helical portions and denatured portions. Now the longitudinal scale is of course much longer. The transversal scale is that for cells. This is perhaps not too surprising since organic materials such as gelatin are involved. The flux tubes could carry magnetic monopole fluxes and in purely formal sense would thus be analogous to magnetic monopoles with space-like momentum in their direction - that is tachyonic monopoles. They would be however actually ordinary systems with non-tachyonic momentum.

The particles possibly causing the tracks cannot be electrically charged since in this case they would not have managed to reach the emulsion. There seems however to be an interaction with magnetic fields since the tracks are parabola. Urutskoev *et al* [H4] propose that tracks are caused by magnetic monopoles. Unfortunately, the predicted parabolic orbit would be in the plane containing the magnetic field lines: the situation is completely analogous to the parabolic motion of projectile in the Earth's gravitational field.

"Tracks" as photographs of magnetic flux tubes?

Consider first the identification of "tracks" (for convenience I will drop the quotation marks in the sequel) as images of magnetic flux tubes.

1. The hypothesis that tracks are photographs of flux tubes explains the "track-ness". In the Earth's magnetic field the thickness of flux tubes is by flux quantization of the same order of magnitude as the thickness of thickest tracks observed for single flux quantum. Flux tube hypothesis seems to be also consistent with the other strange properties of the "tracks". In particular, the composition to random and smoothly curved portion would conform with the idea that also linear molecules are formed around templates defined by magnetic flux tubes.

2. The tracks have been observed to be created in several situations and it is not at all clear whether the exposure to hands in the experiments of Fredericks is absolutely necessary. TGD suggests that the analog of dielectric breakdown associated with nerve pulses (the electric field at cell membrane is two times higher than the electric field inducing di-electric breakdown in air) replaces the strong electric fields causing di-electric breakdown used in the experiments of Urutskoev [H4]. Dark magnetic flux tubes can accompany any kind of matter so that tracks could be also images about the dark magnetic body of an external object rather than that of emulsion. In principle, one cannot exclude the possibility that the presence of the experimenter is decisive in all cases. If so, this would be a new kind of experimenter effect.

3. To what could the abrupt ending of the track correspond in this picture? Magnetic flux tubes cannot end but they can go to another space-time sheet through wormhole contact and apparently disappear. This would indeed take place for the closed flux tubes representing elementary particles and carrying magnetic monopole flux. The flux tubes could quite generally carry a multiple of magnetic monopole flux. They would have rather large scale as compared to the CP_2 scale of 10^4 Planck lengths.

   1. Explanation for parabolic portions of tracks

The presence of parabolic tracks in the plane orthogonal to the external static magnetic fields is very interesting feature to be explained. Parabolic character could be simply due to the simplest non-linear fit to the shape of the flux tube: it is however argued that parabolic character is exact. One should understand why the flux tube is orthogonal to the external magnetic field or magnetic field generated by the emulsion? Could this reflect the geometry of the experimental arrangement?

In TGD framework one can consider a very natural possibility that a constant electric field orthogonal to the external magnetic field is present.

1. In standard physics the presence of the electric field might be excluded easily. In TGD framework simplest space-time sheets representing constant Kähler magnetic fields allow a simple deformation to sheets containing orthogonal electric field. A simple situation (not

necessarily a preferred extremal of Kähler action) corresponds to a space-time sheet $X^4 \subset M^4 \times S^2$, S^2 a geodesic sphere of CP_2. Using spherical coordinates $(u = cos(\Theta), \Phi)$ for S^2 and Cartesian coordinates (t, z, x, y) for M^4, one has $(u = f(x), \Phi = \omega t + ky)$ $(c = 1)$. The non-vanishing components of magnetic and electric fields are apart from a coefficient of proportionality of order unity given by $E_x \equiv J_{0x} = \partial_x u \times \omega$ and $B^z \equiv J_{xy} = \partial_x u \times k$ with $E_x/B_z = \omega/k$. Electric and magnetic fields are orthogonal and the value of the ω/k ratio fixes the electric field strength in terms of the magnetic field strength. In fact, the mere assumption that the CP_2 projection is 2-dimensional implies that electric and magnetic parts of various induced gauge fields are orthogonal.

2. This field would be represented by a space-time sheet at which the flux tubes of the external magnetic are topologically condensed (glued by wormhole contacts). The charged particles inside the flux tube would experience the presence of this electric field as a constant force trying to force them out from the flux tube. If the flux tube adopts a parabolic shape of the orbit of individual charged particle, the electric force is parallel to the flux tube and one has equilibrium situation. *All* charged particles inside flux tube must move with the same velocity at given point of flux tube: this conforms with super-conductivity implying the existence of global order parameter. Note that the dark charged particles inside flux tube would not directly interact with the emulsion or with air so that they can reach the emulsion easily.

3. For non-relativistic motion the equation for the parabolic orbit is $y = x^2/L$, where the length $L = 2mv^2/qE$ characterizes the size scale of the parabola. Parametrizing E in terms of voltage and length L as $E = V_e/L$ one has $eV_c/mc^2 = 2(v/c)^2$. For electron rest energy $m_e c^2 = .5$ MeV and $v/c = 10^{-3}$ one would have $V_c = 1$ V. For proton the electric field would be by a factor 2^{11} stronger for the same orbit parameters.

   For a given electric field the parameters of the parabola allow to distinguish between flux tubes carrying different charged particles since the kinetic energies from the are expected to be different. I have indeed proposed that magnetic flux tubes could serve as a kind of filter allowing to distill ions with different masses at their own magnetic flux tubes: the equilibrium condition would make the flux tubes filters. The cyclotron energy scale $E_c = \hbar_{eff} ZeB/m$ would give a rough guess for the order of magnitude of kinetic energy of the particle: cyclotron energy scale is proportional to h_{eff} so that quite high energies can be considered. eV as a typical atomic energy scale and also as the energy scale of bio-photons (interpreted as decay products of dark photons [K20]) is the first guess for the energy scale.

4. It should be easy to check whether the emulsion is accompanied by electric field and also to deduce bounds for its values. Living matter is electret and one could imagine that gelatin contains some kind of remnants of bio-electric fields - perhaps as dark variants.

2. The decrease of the track thickness with the increase of distance

Urutskoev *et al* [H4] have reported the decrease of the track thickness with the increase of the source distance. Does this mean that the flux tubes photographed are near the source and the reduction of track thickness with distance is an optical effect similar to that for ordinary photographs?

If the flux tubes belong to the magnetic body of emulsion, this explanation fails. It is however easy to invent plausible explanation also in this case. based on a simple model for the quantization of the magnetic flux.

1. The reconnection for flux tubes of the source and emulsion can take place only for flux tubes with same magnetic field strength and by flux conservation same transversal area S. Note that conservation of magnetic flux implies $B \times S = constant$ so that increasing the thickness of flux tube decreases the strength of the magnetic field.

2. If the flux tubes have a fractal structure with flux tubes containing bundles of flux tubes (bundle structure has been observed for the tracks), one can argue that the weaker the magnetic field, the smaller the number of flux tubes in the typical bundle and the smaller

the radius of the bundle if the flux tubes inside bundle have constant density. For dipole field the weakening of the average field with distance could mean that flux tube bundles split to smaller bundles. A "temporary" splitting of at track to a bundle of widely separated tracks has been observed for tracks and would mean reduction of the average magnetic field strength.

3. If the number of grains corresponds to the number of flux tubes within a bundle, the number of flux tubes in the bundle would be thousands. The average size of the grain suggests a diameter of order .34 μ m for the flux tubes. If the magnetic length $L_B = \sqrt{h/eB}$ equals to $L_B = .17$ μm (scaling rule: 1 Tesla corresponds to $L_B = 64$ nm), the magnetic field strength would be 354 Gauss (the Earth's magnetic field has nominal value of .5 Gauss). The external magnetic field of 20 Gauss used by Urutskoev *et al* defines a good candidate for the flux tube radius. For this field single flux tube would correspond to 18-19 crystals.

If this model is on correct track, these photographs could among other things provide means for the detailed study of the quantized dynamics of magnetic fields based on decomposition to flux tubes consisting of flux tubes consisting of...

What could be the source of dark photons?

Photographic emulsion would work as usually by detecting photons. What is clear that the photons must be dark when they scatter from the magnetic flux tubes of the magnetic body of the emulsion. There are however several options for how the dark photons are produced.

1. Ordinary photons from the source could hit the emulsion, transform to dark photons and propagate to the magnetic flux tubes, reflect back, transform to ordinary photons, and interact with the micro-crystals of the emulsion and generate the visible track as the image of the flux tube. Emulsion would take the role possessed by DNA sample in Gariaev's experiments and the external source would take the role of lamps used to generate visible light [K1].

2. Dark photons could also originate from the source. They could arrive along the flux tubes of its magnetic body. In the experimental situations considered these would reconnect with the flux tubes of the magnetic body of the emulsion and scatter from dark matter at them. After this the photons would propagate to the emulsion and transform to ordinary photons and give rise to the image. Reconnection of the flux tubes is the basic mechanism of attention in TGD inspired theory of consciousness and in TGD inspired biology, and also used to explain various findings of Persinger *et al* [K30].

3. The emission of dark photons is expected to take place in critical systems in which large values of effective Planck constant h_{eff} making possible long range correlations can be present. The situations studied (glow discharge plasma processes, exploding wires and foils, low energy discharges in water, super-compression of solid targets using electron beams) indeed seem to be critical. Only the search of monopoles of solar origin at the north pole represents a situation in which criticality is not present in obvious manner (the measurement method might involve criticality to guarantee maximal sensitivity). This kind of situations would generate time varying magnetic fields, whose flux tubes could reconnect with the magnetic flux tubes assignable to the photographic emulsion. This in turn would make possible for dark photons to propagate from source to the emulsion. In some experiments also static magnetic fields are present.

4. What is interesting that the "cold currents" reported already by Tesla in his experiments involving di-electric breakdowns at surfaces of wires of coils could correspond to dark currents propagating along the magnetic flux tubes [L14] [L14]. Most of these experiments correspond to critical situations making possible the manifestation of otherwise hidden new physics. Whether one can see these manifestations of course depends on whether one believes on the reductionistic Bible or not.

Chapter 10

The based view about dark matter at the level of molecular biology

10.1 Introduction

This chapter has been written together with Reza Rastmanesh as a kind of appendix to an article representing TGD based model for language [L143, L144]. The basic idea of the TGD based vision about living matter is that dark matter having effective Planck constant $h_{eff} = nh_0$ ($h = 6h_0$) located at the flux tubes of magnetic body controls ordinary matter: MB would be the boss and biological body the slave. This hypothesis can be justified by number theoretic vision about TGD, which unifies ordinary physics as physics of sensory experience described by real number based physics and the physics of cognition based on p-adic number fields: real and various p-adic number fields are fused to adele.

10.1.1 Physical motivations for the TGD notion of dark matter

The notion of dark matter as control of biomatter emerged before its number theoretic justification.

1. The findings of Blackman *et al* [J28] about the effects of ELF radiation (in EEG frequency range) on vertebrate brain led to the hypothesis that besides protons also ions have dark variants having $h_{eff} = nh_0$ with $h_{eff} = h_{gr}$.

2. Also electrons could have these phases but now the value of h_{eff} would be much smaller and satisfy generalized Nottale hypothesis $h_{eff} = h_{em}$, where h_{em} is the electromagnetic analogue of h_{gr} assignable to flux tubes assigned with valence bonds [L46]. This leads to a model of valence bond [L46] predicting that the value of $h_{eff}/h_0 = n = h_{em}$ increases along the rows of the periodic table. This would explain why the molecules such as proteins containing atoms towards the right end of the rows serve as carriers of metabolic energy and why biologically important ions like C^{++} are towards the left end of the rows.

   The energy scale of dark variants of valence electrons is proportional to $1/heff^2$ so that the orbital radii are scaled up and the identification as a Rydberg atom is the only possibility in the standard physics picture: could dark valence electrons be in question? There is empirical evidence known for decades for the mysterious disappearance of valence electrons of some rare earth metals. The article "*Lifshitz transition from valence fluctuations in YbAl3*" by Chatterjee *et al* published in Nature Communications [L48] discusses the phenomenon for Yb.

   The finding [D31] about misbehaving Ruthenium atoms supports the view that covalent bonds involve dark valence electrons. Pairs of Ru atoms were expected to transform to Ru dimers in thermo-dynamical equilibrium but this did not happen. This suggests that valence electrons associated with the valence bond of Ru dimers are dark in TGD sense and the valence bonded Ru dimer has a higher energy than a pair of free Ru atoms. TGD based explanation [K39] could be justified by a resonant coupling of the dark electron with an

ordinary Rydberg state of the valence electron. In the lowest approximation dark valence electron has energies in the spectrum of ordinary valence electrons so that a resonant coupling with Rydberg states can be considered. The evidence found by Randell Mill [D34] for atoms with an abnormally large scale of binding energy suggests the formula $h = 6h_0$. Color vision is a possible application [L59]. Adelic physics [L50] predicts h_{eff} hierarchy and allows to understand the findings.

3. Nottale hypothesis [E2] introduces the notion of gravitational Planck constant $\hbar_{gr} = GMm/v_0$ and is in the TGD framework identified as a particular value of h_{eff} assignable to gravitational flux tubes [K104, **?**, K83, K18] [L56]. One trivial implication reflecting Equivalence Principle is that the cyclotron energy spectrum $E_c = n\hbar_{gr}eB/m = nGMeB/v_0$ does not depend on the mass m of the charged particle and is thus universal. The energies involved are proposed to be in the range of biophoton energies (at least) suitable for control of the transitions of bio-molecule.

The difference between non-organic and in-organic matter would be the presence of dark protons and electrons. The notions of acids and bases would reduce to the presence of dark protons: pH would characterize the fraction of dark protons. The notion of reduction and oxidation (REDOX reaction) would reduce to dark electrons associated with valence bonds [L46].

In biochemistry the density of dark protons would be much stronger and Pollack effect it in which the irradiation of water in presence of gel phases generates exclusion zones (EZs) as negatively charged regions by transferring every 4th proton to dark proton at flux tubes forming dark proton sequences as dark nuclei. Also dark ions become important in biochemistry, at least positively charged ions would have an important control role in TGD based view about biochemistry.

10.1.2 Realization of the vision about MB as controller of ordinary biomatter

$M^8 - H$ duality [L86, L83] concretizes the general vision. This duality states the representability of space- times as a 4-D surfaces in either complexified M^8 or $H = M^4 \times CP_2$. $n = h_{eff}/h_0$ has interpretation as dimetinsion of extension of rationals and would the degree of a polynomial determining the space-time surface in M^8 as a root of polynomial of degree n. Roots would correspond to different sheets of n-sheeted space-time surface and Galois group of extension would permute the sheets with each other and act as a number theoretic symmetry group. Dark matter states at the flux tubes of B_{end} would be in representations of Galois group and Galois confinement [L102] forcing n-particle states to behave as single unis like hadrons as color confined states.

The model of bio-harmony [L24, L25, L95] based on the icosahedral and tetrahedral geometries in turn predicts that genetic codons correspond to dark photon triplets as 3-chords of lights. The representation of 12-note scale as a sequence of quints reduced by octave equivalence fixes the harmony for a given Hamiltonian cycle and realizes the symmetries of the harmony defined by some subgroup of the icosahedral group.

Combination of 3 icosahedral harmonies with 20 chords and having different symmetries with tetrahedral harmony with 4 chords gives bioharmony 20+20+20+4=64 chords assigned to DNA codons. Amino-acids are identified as orbits of 3-chords under the symmetries of a given harmony, and one obtains 20 amino acids. DNA codons coding for a given amino acid correspond to the chords at the corresponding orbit and the numbers of DNA codons coding for a given amino acid come out correctly.

Bio-harmony assigns the binary aspects of information to the 6 bits of codon and emotional aspects to the bio-harmony characterized by allowed chords fixed by a given Hamiltonian cycle at icosahedron and the unique tetrahedral cycle. The model of bio-harmony requires that the values of B_{end} correspond to those associated with Pythagorean scale and defined by quint cycle.These frequencies would correspond to energies that a molecule must have to serve as a candidate for a basic biomolecule.

In the model of genetic code [L34, L55] identifying codons as dark proton triplets, the numbers of dark proton triplets correspond to numbers of DNA, RNA, tRNA codons and amino acids and one obtains correctly the numbers of DNA and RNA codons assignable to given amino-acid in the vertebrate genetic code. Genes would correspond to sequences of dark proton triplets.

Dark proton triplet would be analogous to baryon and Galois confinement [L102] would force it to behave like a single quantum unit. Dark codons would in turn bind to Galois confined states of the Galois group of extension of the extension associated with the codons.

Galois confinement would be realized also for the dark photon triplets as representation of genetic codons and also for the sequences of N dark-photon representing genes as dark 3N-photon states. Genes would serve as addresses in the communications based on dark $3N$-photon resonances. For communications between levels with the same value of h_{eff} there would be both energy and frequency resonance and for levels with different values of h_{eff} only energy resonance. It is an open question whether for dark-ordinary communications dark photon $3N$-plets transforms to single ordinary biophoton.

The basic hypothesis is that both DNA, RNA, tRNA, and amino acids are paired with their dark analogs, and that energy resonance mediates the interaction between the members of pairs. In this article the goal is to clarify the dark-ordinary pairing and the interaction between the members of the pairs. To achieve this, we first propose some questions below and then synthetize the answers to them.

10.1.3 Questions

In the sequel we will address the following questions about the roles of MB in the biochemistry of the basic biomolecules.

1. Do dark protons appear already in non-organic chemistry? Does acid/base tend to give/bind with a dark proton? The basic process is OH $\to$ O$^-$ +H$_+$. Water represents the basic example containing ions H_3O^+ and OH^-: the dark proton from H_2O would bind to the second H_2O acting in the role of base. pH characterizes the fraction of protons equal to 10^{-7} for $pH = 7$.

   Does the transition to biochemistry mean Pollack effect [I126, L23] in which the fraction of dark protons becomes 1/4 corresponding to $pH = log_{10}(4)$. This would be the case for DNA, RNA, amino-acids, and tRNA also? Are the transitions between dark and ordinary states a key element of biochemistry. Could the gravitational flux tubes of MB take an active role in biochemistry?

2. Could the proton in hydrogen bond be dark? Could length of the hydrogen bond vary corresponding to different values of $h_{eff} = h_{gr}$. Could this explain the behavior of water below 100 C, in particular at physiological temperatures, challenging the standard thermo-dynamical model.

3. Do dark electrons play a role in chemistry as suggested in [L46]? Does oxidation/reduction mean almost giving/receiving a dark valence electron in the valence bond? REDOX reactions are central also in biochemistry. The basic example is combustion in which O==O in presence of hydrocarbon such as sugar C_nH_{2n} gives rise to CO_2 and H_2O and $C_{n-1}H_{2n-2}$. O is reduced so that it almost receives valence electrons from C and H and C and H are in turn oxidized. The notion of electronegativity parametrizes the tendency to receive an electron. Is it possible to state that in inorganic and organic chemistry the electromagnetic part of MB is by far more important than the gravitational part of MB whereas in biochemistry also the gravitational part becomes important.

   Also ions are proposed to appear as dark variants and one can wonder whether the valence electrons of positively charged biologically important dark ions like Ca^{++} are actually dark.

   The following question can be asked about the role of MB in biochemistry of basic biomolecules.

1. Does the energy resonance for dark proton triplets and even for their sequences between biomolecules and their dark variants select the basic biomolecules like DNA, RNA, tRNA, and amino-acids having dark proton counterparts? Base pairs in DNA double strand involve also hydrogen bonds. Could these hydrogen bonds have also dark variants?

2. Dark proton triplets would neutralize the negative charges assignable to the phosphates of DNA and RNA nucleotides and could be imaged as coming from POH$\to$ PO$^-$ +H$^+$ by

a transformation of proton to dark proton by the analog of Pollack effect making DNA negatively charged.

What about the cell membrane, whose lipids have also phosphate ions at their ends? Could this give a higher level representation of the genetic code and genes at cell membrane level making possible dark 3N-photon communications between genome and cell membrae? Or do the dark protons serve at least as an energy storage? In fact, it has been proposed that cell membranes could involve a genetic code [I123].

Microtubules are accompanied by negatively charged GTP molecules possibly associated with tubulins. 6-bit code defined also by DNA codons has been proposed by Hameroff *et al* as a memory code [J77]. Could it be associaed with genetic code represented using dark proton triplets?

3. The amino-acids in proteins should pair with dark variants of amino-acids by energy resonance. Amino-acid backbone does not however carry negative charge. Are the dark protons coming from NH_2 and COOH neutralized by electrons so that one would have dark hydrogens?

4. Also the ATP molecule has a negative charge of 3 units. Is it neutralized by a dark proton triplet serving as a temporary storage of metabolic energy? Could this energy at least partially explain the somewhat questionable notion of the high energy phosphate bond (also dark valence electrons would contribute)? Could ATP$\rightarrow$ ADP liberate metabolic energy by splitting one dark valence bond and transforming one dark proton to ordinary one? Do the dark protons assigned with the proteins serve as metabolic energy storage besides valence electrons, whose reduced Coulombic binding energies also give rise to higher than expected bond energies?

The next sections will be devoted to the possible answers to these questions.

Note: This chapter was prepared in collaboration with Dr Reza Rastmanesh who provided a lot of biological knowhow and made inspiring questions.

10.2 Some number theoretical aspects of quantum biology

In this section the number theoretical aspects of TGD inspired quantum biology relevant to the recent article are considered. The role of the number number theory in TGD inspired view about cognition relying on adelic physics [L50] is not discussed here.

Fig. 10.1 summarises the role of number theory in the TGD inspired vision concerning consciousness, cognition, and quantum biology and **Fig. 10.2** the role of dark matter in TGD inspired quantum biology.

10.2.1 Dark proton representation of genetic code

Fig. 10.3 summarizes the TGD based vision about genetic codes.

Codons as dark nucleons?

The model for codons of genetic code emerged from the attempts to understand water memory [**?**] The outcome was a totally unexpected finding [**?**] the states of dark nucleons formed from three quarks connected by color bonds can be naturally grouped to multiplets in one-one correspondence with 64 DNAs, 64 RNAs, 20 amino acids, and tRNA and there is natural mapping of DNA and RNA type states to amino acid type states such that the numbers of DNAs/RNAs mapped to given amino acid are same as for the vertebrate genetic code.

The basic idea is simple. The basic difference from the model of free nucleon is that the nucleons in question - maybe also nuclear nucleons - consist of 3 linearly ordered quarks - just as DNA codons consist of three nucleotides. One might therefore ask whether codons could correspond to dark nucleons obtained as open strings with 3 quarks connected by two color flux tubes or as closed triangles connected by 3 color flux tubes. Only the first option works without additional
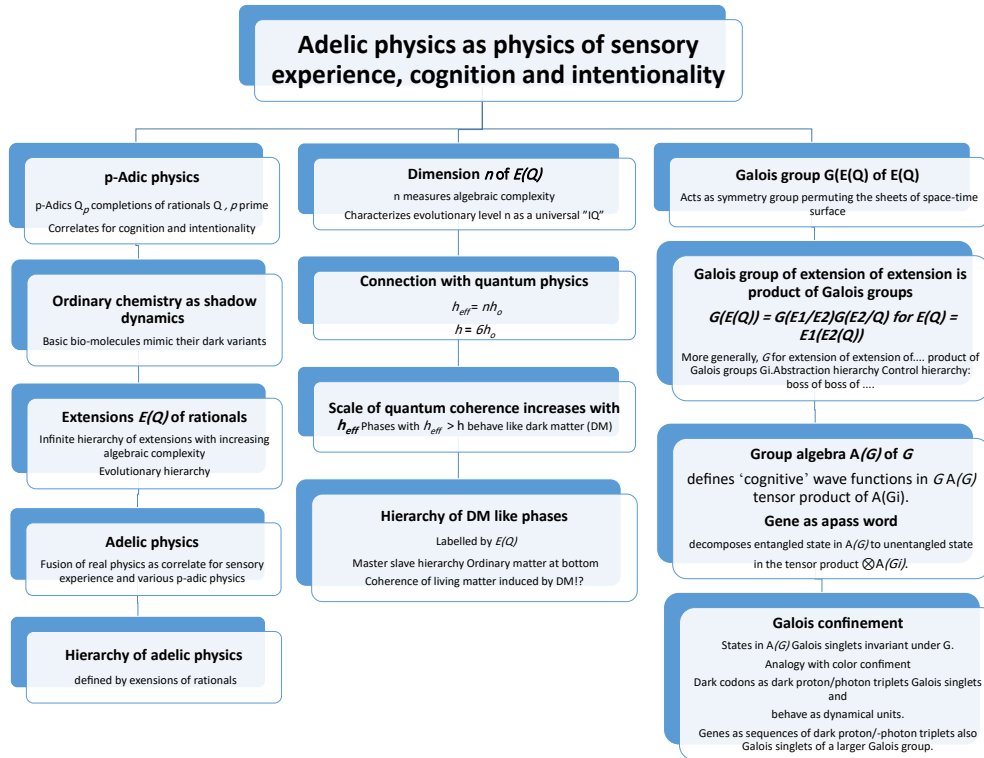
Figure 10.1: Adelic physics as physics of sensory experience, cognition and intentionality

assumptions. The codons in turn would be connected by color flux tubes having quantum numbers of pion or η.

This representation of the genetic would be based on entanglement rather than letter sequences. Could dark nucleons constructed as a string of 3 quarks using color flux tubes realize 64 DNA codons? Could 20 amino acids be identified as equivalence classes of some equivalence relation between 64 fundamental codons in a natural manner? The codons would not be separable to letters but entangled states of 3 quarks anymore.

Genetic code would be defined by projecting DNA codons with the same total quark and color bond spin projections to the amino acid with the same (or opposite) spin projections. The attractive force between parallel vortices rotating in opposite directions serves as a metaphor for the idea. This hypothesis allows immediately the calculation of the degeneracies of various spin states. The code projects the states in $(4\oplus2\oplus2)\otimes(5\oplus3)$ to the states of 4×5 with the same or opposite spin projection. This would give the degeneracies $D(k)$ as products of numbers $D_B \in \{1, 2, 3, 2\}$ and $D_b \in \{1, 2, 2, 2, 1\}$: $D = D_B \times D_b$. Only the observed degeneracies $D = 1, 2, 3, 4, 6$ are predicted. The numbers $N(k)$ of amino acids coded by D codons would be

$$[N(1), N(2), N(3), N(4), N(6)] = [2, 7, 2, 6, 3] \ .$$

The correct numbers for vertebrate nuclear code are $(N(1), N(2), N(3), N(4), N(6)) = (2, 9, 1, 5, 3)$. Some kind of symmetry breaking must take place and should relate to the emergence of stopping codons. If one codon in the second 3-plet becomes stopping codon, the 3-plet becomes doublet. If 2 codons in 4-plet become stopping codons it also becomes doublet and one obtains the correct result $(2, 9, 1, 5, 3)$!
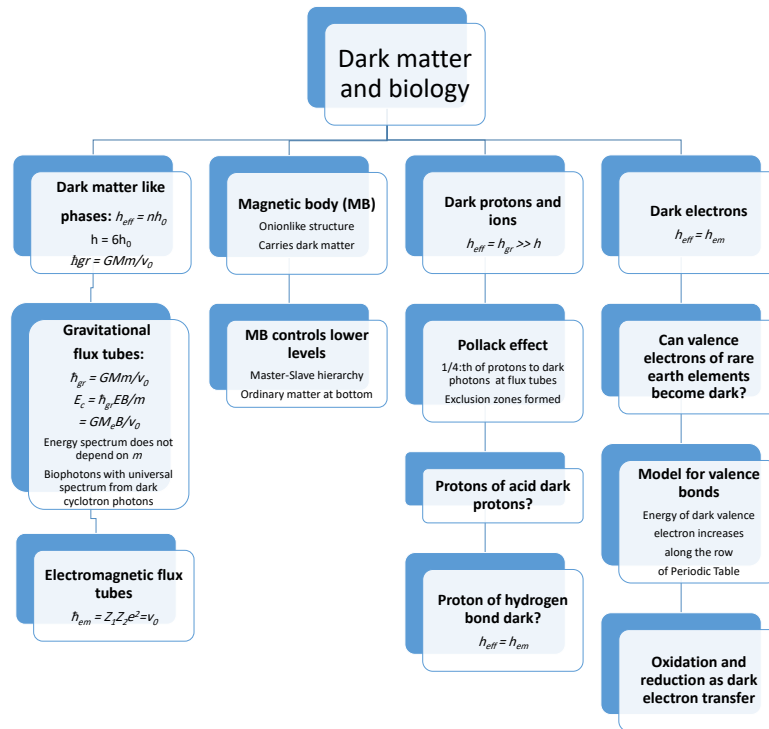
Figure 10.2: Dark matter in TGD inspired quantum biology

Codons as dark proton triplets?

The model of codon as dark nucleon predicts analogs Δ resonances whose masses differ from those of nucleons.

The hint comes from the fact that DNA nucleotides have a negative charge, which is problematic from the point of view of DNA stability. This suggests that dark codons should have a charge of 3 units screenng the charge of the ordinary DNA codon. Pollack effect [?]eans formation of negatively charged exclusion zones as protons are transferred to dark protons at magnetic flux tubes. Could DNA be formed by Pollack effect? Could codons be represented as dark proton triplets?

The problem is that protons however have only 2 spin states: 4 states would be needed as in the case of quarks having also color. Where could the counterparts of spin and color come from?

One could consider adding a neural pion-like and/or ρ_0 meson-like bond connecting neighboring protons. Since ρ_0 has spin 1, this would give 1+3=4 states per bond. However, 2 states are enough and one must get rid of 2 states. The string-like structure of the proton triplet suggests that the rotation group reduces to $SO(2) \subset SO(3)$ so that ρ meson states split into singlets with helicities 0,1,-1. The doublet (-1,1) would serve as the analog of the isospin doublet (u,d) for baryons and enough to achieve a correct effective number $N = 4$ of states per single DNA codon. Helicity would replace isospin and the tensor product states could be constructed effectively as tensor products of 3 representations $2 \otimes 2$.

There is also an issue related to the fermionic statistics. Protons are fermions and the total wave function for them must be antisymmetric. For baryons color singlet property allows this. Can one require statistics in the ordinary sense also now? Or could the effective 1-dimensionality
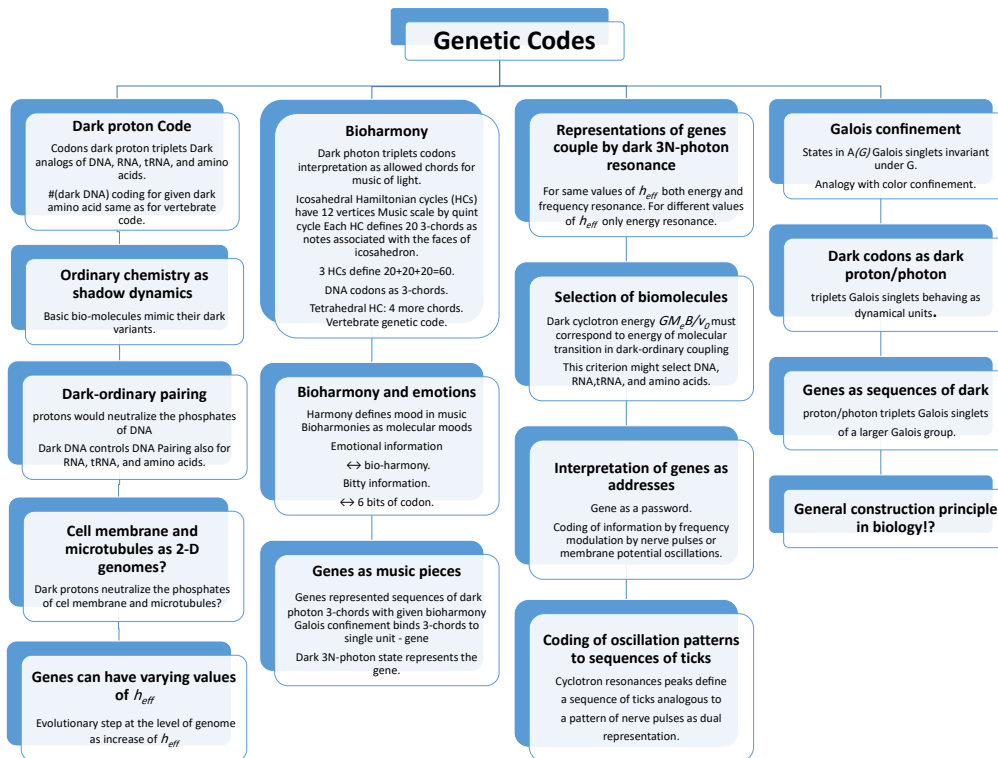
Figure 10.3: Genetic codes in TGD framework

of the magnetic flux tube allow braid statistics?

The following variant gives good hopes about the ordinary statistics.

1. Adelic physics [?]rings in additional discrete degrees of freedom assignable to the group algebra of Galois group of extension of rationals inducing the extensions of p-adic number fields appearing in the adele [?]

2. Galois group acts on the space of space-time surfaces, and one can say that one has wave function at the orbit of the Galois group consisting of space-time sheets. At quantum level quantum states correspond to wave functions in the group algebra of Galois group of extension.

3. The role of color degrees of freedom in helping to achieve correct statistics in the case of baryon could be taken by Galois degrees of freedom. One can even consider the notion of Galois confinement as a generalization of color confinement [?]inding codons as dark proton triplets to dynamical units. Codons should be antisymmetric under exchange of dark protons in Galois degrees of freedom. Also genes as sequences of codons could be bound to dynamical units as Galois singlets. Could this allow ordinary statistics.

One can consider the replacement of u and d quarks with proton and neutron: color degrees of freedom would be missing but also now Galois confinement could come in rescue. Now however the charge screening of DNA by dark DNA would not be complete.

If this picture is correct, genetic code would be realized already at the level of dark nuclear physics or even at the level of ordinary nuclear physics if the nuclei of ordinary nuclear physics

are nuclear strings. Chemical realization of genetic code would be induced from the fundamental realization in terms of dark nucleon sequences and vertebrate code would be the most perfect one. Chemistry would be a kind of shadow of the dynamics of positively charged dark nucleon strings accompanying the DNA strands and this could explain the stability of the DNA strand having 2 units of negative charge per nucleotide. Biochemistry might be controlled by the dark matter at flux tubes.

Cell membrane and microtubules as a higher level representation of genetic code?

Also the representation of genetic code at the level of cell membrane can be considered [L74]. This kind of proposal have been made with different motivations by Okecukwu Nwamba [I123]. The motivation for the current proposal is that the lipids have at their ends negatively charged phosphates just as DNA nucleotides have. The generalization of DNA as a 1-D lattice like structure to a 2-D cylindrical lattice containing nucleotide like units - letters - possibly assignable to lipids and realized as dark protons. Single lipid could be in the role of ribose+nucleotide unit and accompanied by a neutralizing and stabilizing dark proton. For axons one would have cylindrical lattice dark DNA lattice. The two lipid layers could correspond to two DNA strands: the analogs of the passive and active strand.

The finding is that membrane affects protein's behavior. This would be understandable in the proposed pictures 2-D analog of 1-D nucleotides sequences with codons replaced with counterparts of genes as basic units. That lipids are accompanied by phosphates with charge -1 gives the hint. Phosphate charge is neutralized by a dark proton as an analog of a nucleotide.

The notion of Galois confinement identifying genes as units consisting of N dark proton triplets representing genetic codons suggests that genes possibly assignable to the lipid layers of the cell membrane could communicate using dark $3N$-photon sequences with the proteins, genome, RNA and DNA. Dark variants of the control genes could initiate a nerve pulse pattern. An interesting possibility is that ganglions, nucleus like structures assignable to sensory organs and appearing as basal ganglia in brain [I74] could communicate with genes.

Also microtubules have GTPs with charge -3 bound to tubulins. In dynamical instability known as treadmilling the transformation of GTP$\rightarrow GDP$ bound to β tubulin by hydrolysis induces the shortening of the microtubule at minus end whereas the addition of tubulins bound to GTP induces the growth at plus end. Also actin molecules bound to ATP show a similar behavior. Could they be accompanied by dark DNA codons? Are all codons allowed or does the absence of XTP, X= T,C,G mean that only codons of type GGG would be present?

For the dark codons for the cell membrane the p-adic length scale $L(151) \simeq 10^{-8}$ m would correspond to the lipid's transversal size scale and would be the distance between the dark protons. The scale of dark nuclear energy would be proportional to $1/L(151)$ and scaled down by factor $\sim 10^{-3}$ from that for DNA. The energy scale should be above the thermal energy at room temperature about .025 eV. If the energy scale is 2.5 eV (energy of visible photon) for DNA, the condition is satisfied. Note that 2.5 eV is in the bio-photon energy range. For p-adic large scales longer than $L(151)$ thermal instability becomes a problem.

It is interesting to compare the number of codons per unit length for ordinary genetic code (and its dark variant) and for various membranes and microtubules.

For the ordinary genetic code there are 10 codons per 10 nm defining p-adic length scale $L(151)$. This gives a codon density $dn/dl = 10^3/\mu m$ in absence of coiling. The total number of codons in human DNA with a total length $L \sim 1$ meter is of order $N \sim 10^9$ codons. The packing fraction of DNA due to coiling is therefore huge: of order 10^6.

If each lipid phosphate is accompanied by a dark proton and if lipid correspond to square at axonal cylinder with side of length $d = L(151)$ and the radius R of axon corresponds to the p-adic length scale $L(167) = 2.5\mu$ m (also of the same order as nucleus size), there are about $dn/dl = 2\pi(R/d)^2 \sim (2\pi/3) \times 10^4 \sim 1.3 \times 10^5/\mu m$. Axon should have length $L \sim 1$ cm to contain the entire genome.

The same rough estimate applies to microtubules except that there would be one codon per GTP so that the estimate would be 3 times higher if GTP corresponds to length scale $L(151)$ of tubulin molecule. It has been proposed that genetic code is realized at the microtubular level.

The nuclear membrane assumed to have a radius about $L(167) = 2.5\mu$m could represent $N \sim (4/3)R^2/d^2 \sim .8 \times 10^5$ codons. This is a fraction 10^{-5} about the total number of codons. For a neuronal membrane with radius $R \sim 10^{-4}$ meters assignable to a large neuron the fraction would be roughly 10^{-1}. The fraction of dark codons associated with membranes could correspond to genes involved with the control and communication with genome and other cell membranes. Note that the non-coding intronic portion dominates in the genome of higher vertebrates. One can ask whether the chromosome structure is somehow visible in the membrane genome and microtubular genome.

10.2.2 Bio-harmony as a realization of genetic code

TGD leads to a notion of bio-harmony in terms of icosahedral and tetrahedral geometries and 3-chords made of light assigned to the triangular faces of icosahedron and tetrahedron [L24, L25, L95]. The surprise was that vertebrate genetic code emerged as a prediction: the numbers of DNA codons coding for a given amino acid are predicted correctly. DNA codons correspond to triangular faces and the orbit of a given triangle under the symmetries of the bio-harmony in question corresponds to DNA codons coding for the amino acid assigned with the orbit.

Codon corresponds to 6 bits: this is information in the usual computational sense. Bio-harmony codes for mood: emotional information related to emotional intelligence as ability to get to the same mood allowing to receive this information. Bio-harmony would be a fundamental representation of information realized already at molecular level and speech, hearing and other expressions of information would be based on it. For emotional expression at RNA level possibly involved with conditioning at synaptic level see [L57].

Does the generation of nerve pulse patterns by a gene mean at the cell membrane from dark DNA to dark protein map to dark protein (it could be also dark RNA or dark DNA even) associated with the cell membrane. What about communications with RNA and enzymes involved with transcription and translation. Do all basic biocatalytic processes involve them.

What about a generalization of Josephson currents? Dark ions certainly define them but could also dark proton triplets and their sequences associated with proteins give rise to oscillating Josephson currents through cell membrane and therefore to dark Josephson radiation with 3N dark photon units! Proteins themselves need not move much!

The universal language could be restricted to the genetic code which would be realized by dark proton triplets.The 64 codons are formed from 3 20-chord harmonies associated with icosahedron and the unique 4-chord harmony associated with tetrahedron. Bio-harmonies are associated with the so-called Hamiltonian cycles ,which go through every vertex of Platonic solid once. For icosahedron the number of vertices is 12, the number of notes in 12-note scale.

Also tetrahedron, cube, octahedron and dodecahedron are possible and one can consider the possibility that they also define harmonies in terms of Hamiltonian cycles. Dodecahedron would have 5-chords (pentagons as faces) as basic chords and there is only single harmony. Same mood always, very eastern and enlightened as also the fact that scale would have 20 notes.

Also octahedron gives 3-chords (triangular faces) whereas cube gives 4-chords (squares as faces). One can of course speculate with the idea that DNA could also represent this kind of harmonies: sometimes the 3N rule is indeed broken, for instance for introns.

Galois confinement [L103] allows the possibility to interpret dark genes as sequences of N dark proton triplets as higher level structures behaving like a single quantal unit. This would be true also for the corresponding dark photon sequences consisting of 3N dark photons representing the gene in bio-harmony as an analog of a music piece consisting of 3-chords and played by transcribing it to mRNA.

The picture can be viewed even more generally. Any discrete structure, defining graph, in particular cognitive representation providing a unique finite discretization of space-time surface as points with the coordinates of the 8-D embedding space coordinates in the extension of rationals, defines harmonies in terms of Hamiltonian cycles. Could also these harmonies make sense? The restrictions of the cognitive representations to 2-D partonic 2-surfaces would define something analogous to bio-harmony as Hamiltonian cycle of 2-D graph (Platonic surfaces solids can be regarded as 2-D graphs). The interpretation as representations of Galois groups and the notion of Galois confinement is possible although one loses the symmetries of the Platonic solids allowing to identify genetic code.

Brief details of the genetic code based on bio-harmony

TGD suggests several realizations of music harmonies in terms of Hamiltonian cycles representing the notes of music scale, most naturally 12-note scale represented as verticehttps of the graph used. The most plausible realization of the harmony is as icosahedral harmony [L24, L25].

1. Icosahedron (for basic facs see the Wikipedia article) has 12 vertices and Hamiltonian cycle as a representation of 12-note scale would go through all vertices such that two nearest vertices along the cycle would differ by quint (frequency scaling by factor 3/2 modulo octave equivalence). Icosahedron allows a large number of inequivalent Hamiltonian cycles and thus harmonies characterized by the subgroup of the icosahedral group leaving the cycle invariant. This group can be Z_6, Z_4, or Z_2 which acts either as a reflection group or corresponds to a rotation by π.

2. The fusion of 3 icosahedral harmonies with symmetry groups Z_6, Z_4 and Z_2 gives 20+20+20=60 3-chords and 3+1 + 5 + 10 =19 orbits of these under symmetry group and almost vertebrate genetic code when 3-chords are identified as analogs of DNA codons and their orbits as amino acids. One obtains counterparts of 60 DNA codons and 3+1 + 5 + 10 =19 amino acids so that 4 DNA codons and 1 amino acid are missing.

3. The problem disappears if one adds tetrahedral harmony with 4 codons as faces of tetrahedron and 1 amino acid as the orbit of the face of tetrahedron. One obtains 64 analogs of DNA codons and 20 analogs of amino acids: this harmony was coined as bio-harmony in [L24, L25]. The predicted number of DNA codons coding for given amino acid is the number of triangles at the orbit of a given triangle and the numbers are those for genetic code.

4. How to realize the fusion of harmonies? Perhaps the simplest realization found hitherto is based on the union of a tetrahedron of 3 icosahedrons obtained by gluing tetrahedron to icosahedron along its face which is a triangle. The precise geometric interpretation of this realization has however missing and some possibilities have been considered. The model could explain the two additional amino acids Pyl and Sec appearing in Nature [L24, L25] as being related to different variant for the chemical counterparts of the bio-harmony.

   There is also a slight breaking of symmetries: ile 4-plet breaks into ile triplet and met singlet and trp double breaks into stop and trp also leu 4-plet can break in leu triplet and ser singlet. This symmetry breaking should be understood.

10.2.3 Galois group of space-time surface as new discrete degrees of freedom

Galois confinemenent

The problem is to understand how dark photon triplets occur as asymptotic states - one would expect many-photon states with a single photon as a basic unit. The explanation would be completely analogous to that for the appearance of 3-quark states as asymptotic states in hadron physics - the analog of color confinement [L104]. Dark photons would form Z_3 triplets under the Z_3 subgroup of the Galois group associated with corresponding space-time surface, and only Z_3 singlets realized as 3-photon states would be possible.

The invariance under $Gal(F)$ would correspond to a special case of Galois confinement, a notion introduced in [L102] with physical motivations coming partially from the TGD based model of genetic code based on dark photon triplets.

Cognitive measurement cascades

Quantum states form Galois group algebra - wave functions in Galois group of extension E. E has in general decomposition of extension E_1 as extension of E_2 as extension of ... to a series . Galois group of E has decomposition to product of $Gal(E) = Gal(E/E_1)Gal(E_1)$ and same decomposition holds true for $Gal(E_1)$ so that one has hierarchy of normal subgroups corresponding extension of extension of...hierarchy defined by a composite polynomial $P(x) == P_1(P_2(x))$ with P_2 having similar representation. P defines in M^8 picture the space-time surface. This maps a tensor product

composition for group algebra and the factors of group algebra entangle. SSFR corresponds to a cognitive quantum measurement cascade: SSFR in $Gal(E/E_1)$, SSFR in $Gal(E_1/E_2)$ etc.. The number theoretic measurement cascades for purely number theoretic Galois degrees of freedom are discussed in [L105].

Could this cascade be analogous to the parsing of a linguistic or mathematical expression as cognitive measurements proceeding from higher to lower abstraction levels? Could the cascade correspond to a sentence S_1 about a sentence S_2 about ... such that one substitutes a concrete sentence for S_1 first, then to S_2, etc...? This is indeed suggested by the cascade of SSFRs since $h_{eff}/h_0 = n$ is the dimension of E_n.

Could cascade of flux tubes decaying to smaller flux tubes with smaller value of h_{eff} should correspond to this hierarchy. Certainly this is linguistics but the sentence as argument could correspond to several sub-sentences - different flux tubes. Could a neural pathway defined by the branching axon correspond to a concretization of this kind statement about statement (or multistatement, perhaps nerve pulse pattern generated by nerve pulse patterns arriving to a given neuron) about...

10.2.4 Energy and frequency resonance as basic elements of dark photon communications

Dark photon realization of genetic code leads to a view about fundamental linguistic communication based on resonance and we will write a separate paper connecting TGD with language soon. Two systems can be in communication when there is resonance. $E = h_{eff} f$ and energy conservation implies

$$h_{eff,1} f_1 = h_{eff,2} f_2 \ . \tag{10.2.1}$$

For $h_{eff,1} = h_{eff,2}$, energy conservation implies that both energies and frequencies are identical: $E_1 = E_2$ and $f_2 = f_2$. Both energy and frequency resonances in question.

In the general case one has $f_1/f_2 = h_{eff,2}/h_{eff,1}$ and frequency scaling takes place. The studies of water memory lead to the observation that this kind of phenomenon indeed occurs [J27]. The communications of dark matter with ordinary matter and those between different values of h_{eff} involve only energy resonance. Frequency and wavelength scaling makes it possible for long scales to control short scales. Dark photons with EEG frequencies associated with the big part of MB transform to bio photons with a wavelength of say cell size scale and control dynamics in these short scales: for instance, induce molecular transitions. This is impossible in standard physics.

The resonance condition becomes even stronger if it is required there is a large number of biomolecules in resonance with dark matter realized as dark variants of biomolecules and dark ions. Cyclotron resonance energies are proportional to $\hbar_{eff}$ characterizing magnetic flux tubes and to the valued of the magnetic field strength dictated by the quantization of the monopole flux quantization by the thickness of the flux tube which can be do some degree varied by varying the thickness of the flux tube giving rise to frequency modulation.

The findings of Blackman *et al* [J28] suggest that $B_{end} = 0.2$ Gauss defines an important value in the spectrum of B_{end} values. It could correspond to the field strength for the predicted monopole flux part of the Earth's magnetic field $B_E \simeq .5$ Gauss not allowed by Maxwell's theory. Besides B_{end} there would also be a non-monopole flux part allowed also in Maxwell's theory. Monopole flux part requires no currents as sources: this allows the understanding of the presence of magnetic fields in cosmological scales and also why B_E has not dissipated away long time ago [L29].

There are however indications that the value B_{end} is quantized and is proportional to the inverse of a biologically important p-adic length scale and thus would be quantized in octaves. This could relate directly to the octave equivalence phenomenon in music experience. The model of bio-harmony [L24, L25, L95] suggests a further quantization of the octave to Pythagorean 12-note scale of music. This would not be only essential for the music experience but communications of emotions and molecular level using the music of light.

Selection of basic biomolecules by energy resonance

The dark particles must have energy resonance with bio-molecules in order to induce their transitions. This seems to pose extremely strong conditions possibly selecting the bio-molecules able to form interacting networks with dark matter and with each other. One expects that only some amino acids and DNA type molecules survive.

Nottale's hypothesis provides a partial solution to these conditions. Nottale proposed the notion of gravitational Planck constant

$$\hbar_{gr} = \frac{GMm}{v_0} \qquad (10.2.2)$$

assignable in TGD to gravitational flux tubes connecting large mass M and small mass m and v_0 is velocity parameter. The gravitational flux tube presumably carries no monopole flux. The TGD based additional hypothesis that one has equals to

$$\hbar_{gr} = h_{eff} = nh_0 \quad . \qquad (10.2.3)$$

This implies that the cyclotron energy spectrum

$$E_c = n\hbar_{gr}\frac{eB}{m} = n\frac{GM}{v_0}eB \qquad (10.2.4)$$

of the charged particle does not depend at all on its m. Therefore in a given magnetic field, say B_{end}, the cyclotron resonance spectrum is independent of the particle.

The energy resonance condition reduces to the condition that the charged ion or molecule has some cyclotron energy coming as a multiple of fundamental in its spectrum in the spectrum of its transition energies. Even this condition is very strong since the energy scale for cyclotron energy in B_{end} is in the bio-photon energy range containing energies in visible and UV. The fact that bio-photons have a quasi-continuous spectrum strongly suggests that B_{end} has a spectrum. The model of bio-harmony [L19, L75] suggests that the values of B_{end} correspond to Pythagorean scale constructible by quint cycle familiar for jazz musicians that is by taking $(3/2)^k$ scalings of the fundamental frequency and by projecting to the basic octave by octave equivalence.

The above simplified picture is formulated for single dark photon communications. The dark proton and dark photon realizations of the genetic code requires 3-resonance that is a simultaneous energy resonance for the 3 members of dark photon triplet. In dark-dark pairing also frequency resonance is possible. In dark-ordinary pairing frequency increases and couples long scales with short scales. Also resonant communications between genes with N codons involving $3N$ dark photon frequencies must be possible. This requires new physics provided by number theoretical vision.

What happens in the cyclotron resonance?

3 cyclotron energies for flux tubes characterize dark 3-proton triplet and Nottale's hypothesis predicts that they depend on the values of B_{end} for the flux tubes only. Bio-harmony suggests that the spectrum of frequencies and thus B_{end} corresponds to Pythagorean 12-note scale for a given octave. The allowed chords of bioharmy would characterize the emotional state at the molecular level and correspond to the holistic emotional aspects of the communication beside the binary information.

The resonance would require that the dark cyclotron energy changes are equal to corresponding energies in molecular transitions. Galois confinement [L102] makes possible also 3-N resonance. The resonance condition would select basic biomolecules and the ability of dark analogs of biomolecules to simultaneously resonate with several biomolecules would give additional conditions. In particular this would select DNAs and amino acids.

An open question is whether the coupling to ordinary biomolecules involves a transformation of a dark photon triplet or an N-plet to a single ordinary photon. For instance, does the sum of the 3 cyclotron excitation energies appear in the coupling of dark 3-proton state to amino acid in

protein? This would have an analog as 4-wave coupling [D10] in laser physics allowing in biology the transformation of dark photon triplet to single biophoton/or 3 bio-photons or *vice versa*. 6-wave coupling of laser physics would be analogous to the coupling of ordinary 3-photon state to dark 3-photon and back to ordinary 3-photon state.

The resonance itself would mean a process in which dark 3-proton cyclotron excitation returns to the ground state and generates dark 3-photon transforming transforming to ordinary photon (or 3-photon) and absorbed by the ordinary codon or amino acid excitation to hither energy state. This state would in turn emit an ordinary photon transforming to dark 3-photon absorbed by dark codon. This mechanism generalizes to 3N-proton states representing genes or dark proteins.

10.3   Some applications

10.3.1   How to understand the pairing between basic biomolecules and their dark variants?

There are interesting questions concerning the analogs of transcription and translation. Could dark DNA send signals also to dark RNA and amino acids and dark RNA to dark amino acids and dark tRNA? Could 3-photon resonance make it possible for biomolecules to find each other in the molecular crowd as proposed. This would be possible when the moods (bio-harmonies are the same - only an unhappy person can really understand an unhappy person!). For genes the 3-flux tube would be replaced with 3N-flux tube made possible by Galois confinement [L102] .

Where do the dark proton sequences associated with proteins come from?

In the formation of protein 3 dark protons drop to a larger space-time sheet. The charges of amino acid residues vary in sign, vanish, or they are neutral, polar, or non-polar. Therefore the dark proton triplets must somehow be associated with the protein backbone as they do in the case of DNA and RNA. This implies that it is ionization of acidic groups OH (as in case of phosphates in DNA) or NH_2. The pairing with the residues would come from 3-photon cyclotron resonance.

Where do the dark protons come from? The backbone of protein is in the same role as sugar phosphate backbone in DNA and RNA. Amino acid residues are in the same roles as DNA nucleotides.

1. Amino acids are acids: NH_2 and COOH groups make them acidic. They tend to release protons and become negatively charged. They could give dark protons. In the formation of protein $NH_2 \rightarrow NH$: one proton and electron lost. Does the proton come dark?

   Where does the electron go? Is it also dark and bound with a dark proton to form a dark atom? This kind of option in the case of the TGD based model for cold fusion [L27, L43] involving dark dark proton sequences in a smaller scale.

2. C-OH loses H as C-O-N is formed. Both electron and proton are lost. Also this proton could become dark and bind with the dark electron to form dark hydrogen atom.

3. Where does the third dark proton come from? Is also NH in C-NH of the peptide acidic? Can it lose a proton, which becomes dark? Just as in the case of DNA codon, electrons would neutralize the dark proton. One would have instead of a dark proton sequence a dark H sequence. The additional charge of amino acid can be positive or negative and its possible polarity relates to the residues and to chemistry. The backbone would serve as the interface between dark matter and chemistry. The resonant interaction between the dark amino acid and residue would give the pairing between amino acid and its dark counterpart.

Denaturation of proteins and DNA

One can wonder how the denaturation of proteins and DNA could relate to dark protons.

1. Do the dark hydrogens become ordinary in the case of protein? h_{eff} would be reduced and the protein would decay. The energy liberated from dark protons and be used to store metabolic energy in the catabolism of proteins.

2. In the denaturation of DNA double strand hydrogen bonds between strands are lost. This also happens in DNA strand opening during transcription and translation. This cannot relate to a loss of dark proton sequences, which would lead to depolymerization.

   Why does the loss of hydrogen bonds lead to the denaturation? Is there binding between dark codon sequences inducing the formation of hydrogen bonding? Is Galois singletness for Z_3 replaced with Z_6 singletness so that a bound state of 2 dark proton triplets corresponding to codon and conjugate would be formed: this would be codon pairing at the level of the dark genome. This is considered in [L102].

Hydrogen bonds and energy resonance

If also hydrogen bonds involve dark proton, there should be an energy resonance in which the dark proton returns from an excited cyclotron state and gives energy to the molecule to which it is bound and excites it. This would then decay to ground state and give the energy back to the dark proton. This would be kind of quantum tennis.

Hydrogen bonds would be also present between the paired bases: depending on the base pair their number would be 2 or 3. These dark protons would not correspond to those associated with dark DNA strands. An interesting question is how important the pairing of dark DNA strands and analog of hydrogen bonds of base pairs is and whether it relates to the energetics assigned with hydrogen bonds.

For instance, one can ask why A-T pairing by hydrogen bonds rather than A-C pairing is good.

1. Suppose that the dark codons DA and DT have the same 3-frequency giving rise to frequency resonance between them so that they can pair. DA and DC do not have the same 3-frequency and cannot pair. Pairing is therefore unique at the dark level.

2. The energy resonance condition assigns to a dark codon a unique codon so that one obtains only A-T pairing induced by dark pairing.

10.3.2 Does high energy phosphate bond involve 3 dark protons?

High energy phosphate bond plays a key role in the modelling of ATP hydrolysis [I3] in the framework of standard chemistry. The official view is that everything is well-understood but for instance Ling has criticised both the notion of the high energy phosphate bond and the reduction to the molecular level [I96, I97, I64, I89, I90] and also emphasised the importanec of a network like structures assignable to the cellular water: in TGD these networks would relate to MB. The work of Ling is discussed from TGD point of view in [L16, L17] [K47, K48].

From the TGD point of view the notion of high energy phosphate bond would be a mistake at the level of fundamental physics: dark matter and MB would be neglected. Thermo-dynamical chemistry can cope with this phenomenologically by introducing the notion of chemical potentials effectively describing the presence of dark matter. What is lost is quantum coherence in longer than atomic scales needed to really understand life.

The energy carried by 3 dark protons should replace the notion of high energy phosphate bond. Pollack effect indeed requires energy feed and this energy would go to dark protons taken from water.

Remark: Pollack effect would be an extreme example of adicity. Every fourth proton would become dark proton at flux tubes. pH would be $log_{10}(4)$! Also ordinary acidity could mean presence of dark protons but their number would be extremely small: one has fraction 10^{-7} for $pH = 7$.

This view would hold also more generally. The dark protons associated with proteins would also serve as a metabolic energy storage. In the denaturation this energy would be liberated. This happens in composts in which the organic material decays and causes heating of the compost. Of course, also the valence bonds which are dark carry energy as energy of dark electrons: by $h_{eff} > h$ the Coulombic bindin energy would be reduced and the energy of the valence bond would increase.

ATP→ADP and also ADP→ AMP [I50] are possible. Dark electrons associated with the valence bonds could contribute to bond energy since large $\hbar$ reduces the negative Coulomb interaction energy assignable to the bond.

Also the dark protons associated with the phosphates could contribute the energy assigned usually with high energy phosphate bond. Pollack's finding [I126] about the formation of exclusion zones (EZs) in presence of irradiation, most effectively IR radiation, led to the TGD based model. A considerable fraction of protons (fraction of 1/4) would be transferred to dark protons at the dark flux tubes. This requires (metabolic) energy and IR radiation would provide it and the energy is stored as energy of dark protons. Hence the pure chemistry based view about high energy phosphate bond would be wrong.

ATP has three phosphates and negative charge of -3 units. It would be screened by charges of 3 dark protons at the flux tube associated with ATP defining possibly a dark DNA codon (adenine triplet?). Dark RNA is not allowed since RNA does not allow A but U instead of it. In ATP $\rightarrow$ ADP the energy is given as a photon to the enzyme catalyzing the reaction allowing to overcome activation energy barrier. In microtubules one has GTPs binding stably to α tubulins but not β tubulins.

Microtubules (MTs) define an interesting candidate for the realization of genetic code. One can also try to understand MTs and their dynamics in terms of Galois confinement.

1. The model of 6-bit memory code [J77] discussed by Hameroff *et al* relies on the hexagonal lattice formed by tubulin dimers consting of a pair of α and β tubulins, the 6-foot structure of CaMKII kinase domains, and the fact that the hexagon and CaMKII fit nicely together. The dynamical tubulins must be β tubulins for which the phosphorylation is not stable. The phosphorylation state of a given foot of the CamKII kinase domain represents a single bit so that CaMKII stores 6 bits. Its attachment at the hexagon of 6 tubulin dimers containing one tubulin dimer at is center could transfer the GTPs and thus 6 bits of information to the center tubulin. The proposed interpretation is as a transfer of information from neuronal to microtubular level involved with the synaptic learning.

2. The TGD inspired question is whether the CaMKII kinase domains are accompanied by dark proton triplets transferred to the tubulin dimer at the center of the hexagon so that microtubules would provide a 2-D representation of genetic code. If CamKII affects only the dark codon at the center of the hexagon, the center hexagon can behave as indepent 6-bit units making possible 2-D lattice representation of the genetic code. This framework does not allow charge neutrality, and microtubules are indeed negatively charged having positively charged and negatively charged ends. Second option would be that the stable GTPs associated with α tubulins define an analog of genome with single codon per GTP.

3. GTPs at the minus end of MT stabilize it, and GTP $\rightarrow$ GDP transition liberating energy occurring for β tubulins causes the thread mill instability illustrated by a video of the Wikipedia article about MTs. The 13 linear strands of tubulin dimers separate and bend radially outward. Are the 13 tubulin strands Galois confined states of tubulin dimers? Do also the 13 strands form a Galois confined state? Does the liberated energy overcome the activation energy barrier against the decay to 13 separate tubulin strands?

   The video of the Wikipedia article illustrates the formation of the structure. Could the decay correspond to a cascade of cognitive measurements leading from a state in Galois group algebra to an entangled product state in the tensor product of states assignable to the group algebras of normal Galois subgroups associated with an extension of extensions of ... of rationals [L105].

The energetics at the dark proton flux tube

The energetics of the flux tube containing 3 dark protons must be considered.

1. Consider first the Coulombic interaction energy between dark protons. The interaction energy includes Coulombic interaction energy of nearest neighbor dark protons with distance R and those with distance of 2R.

   (a) If the flux tube is open, then we have

$$E_c = \frac{2e^2}{R} + \frac{e^2}{2R} = \frac{5}{2}\frac{e^2}{R} \equiv \frac{5}{2}E_0. \tag{10.3.1}$$

(b) If the flux tube is closed one has

$$E_c = 3E_0 \quad . \tag{10.3.2}$$

2. There is also strong interaction energy (one has a dark nucleus) . Strong interaction is short ranged.

   (a) If the flux tube is open one has strong interaction energy $2E_s$ and total energy is

   $$E_{open} = \frac{5}{2}E_0 + 2E_s \quad . \tag{10.3.3}$$

   (b) If the flux tube is closed one has

   $$E_s = 3E_0 + 3E_s \quad . \tag{10.3.4}$$

3. There is also the total negative Coulomb interaction energy of dark protons with the total charge of phosphates.

   $$E(c, N) = K(N)E_P \quad , \tag{10.3.5}$$

   where E_P is interaction energy between dark proton and phosphate. $N = 3, 2, 1$ for ATP, ADP, AMP If the dark protons interact as independent entities with 3 different phosphates one has $K = N$. If both ATP and protons act as single charged entities this energy one has $K = N^2$

4. The total energies for ATP, ADP, AMP are given by

   $$\begin{aligned}
   E_{open,3} &= \tfrac{5}{2}E_0 + 2E_s + K(3)E_P \quad , & E_{closed,3}(ATP) &= 3E_0 + 3E_s + K(3)E_P \quad . \\
   E_{open,2} &= E_0 + E_s + K(2)E_P \quad , & E_{closed,3}(ATP) &= E_0 + E_s + K(2)E_P \quad . \\
   E_{open,2} &= K(1)E_P \quad , & E_{closed,3}(ATP) &= K(1)E_P \quad .
   \end{aligned} \tag{10.3.6}$$

   where $K = N$ or $K = N^2$. Note that for $N = 1$ there is no difference between open and closed cases.

5. What happens in ATP→ADP and ADP→AMP? One organic phosphate (P) transforms to inorganic phosphate ion P_i without dark proton and one dark proton is lost. There are two left. Energy is liberated. There are also other contributions but let us forget them for a moment. The energy liberated is $E \simeq .5$ eV, metabolic energy quantum, energy of an IR photon.

   The liberated energy is in various cases

   $$\begin{aligned}
   \Delta E_{open}(ATP) &\to ADP) = \tfrac{3}{2}E_0 + E_s + [K(3) - K(2)]E_P \quad , \\
   \Delta E_{closed}(ATP &\to ADP) = 2E_0 + 2E_s + [K(3) - K(2)]E_P \quad , \\
   \Delta E(ADP &\to AMP) = E_0 + E_s + [K(2) - K(1)]E_P \quad .
   \end{aligned} \tag{10.3.7}$$

Empirical input

The reconstruction of ATP requires 1 dark proton and free energy about $\Delta G = -.5$ eV is needed. Actually 3 or 4 protons arriving through the cell membrane and getting kinetic energy in the membrane potential are used. Where does the surplus energy go? Or is there any surplus energy at all?

1. Mitochondrial membrane potential for proton which is determined by Coulomb potential and chemical potential due to the proton concentration difference at two sides of the membrane is about .15 eV [I68]. Multiplying this by the number of protons 3 (4) gives .45 eV (0.5 eV) so that 3 dark protons are needed and 1 goes to ADP to give ADP. This gives a nice fit in both cases.

2. It is claimed that the free energy ΔG liberated in ATP$\rightarrow$ ADP is the same as in ADP$\rightarrow$ AMP. If ΔS matters, one has for the liberated free energy - metabolic energy currency -

$$\Delta G = \Delta E + T\Delta S \ . \tag{10.3.8}$$

$\Delta G = -.5eV < 0$, the nominal value of metabolic energy currency, holds true approximately.

Can the free energies liberated in ATP$\rightarrow$ ADP and ADP $\rightarrow$ AMP be the same?

The condition that the metabolic energies as free energy changes are same for various options gives the following conditions.

1. For open and closet flux tube option one would obtain the condition:

$$
\begin{array}{ll}
Open & \frac{3}{2}E_0 + E_s + [K(3) - K(2)]E_P + T\Delta S(ATP) \rightarrow ADP) = \\
& E_0 + E_s + [K(2) - K(1)]E_P + T\Delta S(ADP \rightarrow AMP) \\
Closed & 2E_0 + 2E_s + [K(3) - K(2)]E_P + T\Delta S(ATP \rightarrow ADP) = \\
& E_0 + E_s + [K(2) - K(1)]E_P + T\Delta S(ADP \rightarrow AMP) \ .
\end{array}
\tag{10.3.9}
$$

We obtain the following results form $K = N^2$ and $K = N$ options respectively:

$$
\begin{array}{ll}
(Open, K = N^2): & E_0 = -10E_P - 2X \ , \\
(Open, K = N): & E_0 = -2X \ , \\
(Closed, K = N^2): & E_0 + E_s = -2E_P - X \ , \\
(Closed, K = N): & E_0 + E_s = -X \ , \\
& X = (\Delta S(ATP \rightarrow ADP) - \Delta S(ADP \rightarrow AMP)) \ .
\end{array}
\tag{10.3.10}
$$

For $K = N^2$ option E_0 is positive even when $X = 0$ is true. For $K = N$ $E_0 = 0$ holds true for $X = 0$ and one must have $X < 0$ meaning that the entropy increase in ADP$\rightarrow AMP$ is larger than in ATP$\rightarrow ADP$.

2. One obtains the following values for E_0 in various cases. All terms are manifestly positive in the expressions as they should be.

$$
\begin{array}{ll}
(Open, K = N^2): & E_0 = -10E_P - 2X \ , \\
(Open, K = N): & E_0 = -2X \ , \\
(Closed, K = N^2): & E_0 = -2E_P - X - E_s \\
(Closed, K = N): & E_0 = -X - E_s \ , \\
X = (\Delta S(ATP \rightarrow ADP) - \Delta S(ADP \rightarrow AMP)) \ .
\end{array}
\tag{10.3.11}
$$

3. Liberated free energy can be positive in all cases unless $E_P < 0$ has too large a magnitude.

$$
\begin{aligned}
(Open, K = N^2): \quad & \Delta G = -7E_P - 2X + Y \ , \\
(Open, K = N): \quad & \Delta G = E_P - 2X + Y \ , \\
(Closed, K = N^2): \quad & \Delta G = -E_P - X + Y \ , \\
(Closed, K = N): \quad & \Delta G = E_P - X + Y \ , \\
& X = -T(\Delta S(ATP \to ADP) - \Delta S(ADP \to AMP)) > 0 \ , \\
& Y = T\Delta S(ADP \to AMP) > 0 \ .
\end{aligned}
\tag{10.3.12}
$$

One can argue that $\Delta S > 0$ in both reactions since the number of $h_{eff}/h_0 > 0$ protons decreases and the "IQ" of the system decreases. Hence one has $Y > 0$. The term E_P in $K = N$ case is negative. The term proportional to X is positive for all cases if $X < 0$ is true. This would mean that $\Delta S(ATP \to ADP) < \Delta S(ADP \to AMP)$. Entropy would increase more in the latter reaction. $K = N^2$ options are favored and the most favored is (Open, $K = N^2$) option: open flux tube with 3 dark protons interacting with phosphate charges like single charge of 3 units as the identification as a Galois confined state suggests.

Chapter 11

Are dark photons behind biophotons?

11.1 Introduction

I have written already earlier about bio-photons [K86] and proposed that bio-photons result when dark photons with large value $\hbar_{eff}$ of effective Planck constant and large wavelength transform to ordinary photons with the same energy. The recent progress in understanding the implications of basic vision behind TGD inspired theory of consciousness [L15] [L15] served as a motivation for a complementary treatment from different perspective.

     The recent progress in understanding the implications of basic vision behind TGD inspired theory of consciousness [L15] [L15] served as an additional motivation for a complementary treatment.

1. The anatomy of quantum jump in zero energy ontology (ZEO) allows one to understand basic aspects of sensory and cognitive processing in the brain without ever mentioning the brain. Sensory perception - motor action cycle with motor action interpreted as time-reversed sensory perception directly reflects the fact that state function reductions occur as sequences to the same boundary of causal diamond (CD) (which itself or rather, quantum superposition of CDs, changes in the process such that either the upper or lower boundaries of all CDs involved are localized at the same light-cone boundary). The first reduction of sequence corresponds to genuine state function reduction and the next induce changes only at the second boundary giving rise to experience flow of time and arrow of time.

2. Also the abstraction and de-abstraction processes in various scales which are essential for the neural processing emerge already at the level of quantum jump. The formation of associations is one aspect of abstraction since it combines different way to experience the same object. Negentropic entanglement of two or more mental images (CDs) gives rise to rules in which superposed n-particle states correspond to instances of the rule. Tensor product formation generating negentropic entanglement between new mental images and earlier ones generates longer sequences of memory mental images and gives rise to negentropy gain generating experience of understanding, recognition, something which has positive emotional coloring. Quantum superposition of perceptively equivalent zero energy states in given resolution gives rise to averaging. Increasing the abstraction level means poorer resolution so that the insignificant details are not perceived.

3. Various memory representations should be approximately invariant under the sequence of quantum jumps. Negentropic entanglement gives rise to this kind of stabilization. The assumption that self model is a negentropically entangled system which does not change in state function reduction, leads to a problem. If the conscious information about this kind of sub-self corresponds to change of negentropy in quantum jump, it seems impossible to get this information. Quite generally, if moment of consciousness corresponds to quantum jump and thus change, how it is possible to carry conscious information about quantum state?

Interaction free measurement however allows to circumvent the problem: non-destructive reading of memories and future plans becomes possible in arbitrary good approximation.

This memory reading mechanism can be formulated for both photons and photons and these two reading mechanisms could correspond to visual memories as imagination and auditory memories as internal speech. Therefore dark photons decaying to bio-photons could be crucial element of imagination and the notion bio-phonon could also make sense and even follow as a prediction.

The observation that bio-photons seem to be associated only with the right hemisphere [J58] [K30] suggests that at least some parts of the right hemisphere prefer dark photons and are thus specialized to visual imagination: spatial relationships are the speciality of the right hemisphere. Some parts ofthe left hemisphere at least might prefer dark phonons: left hemisphere is indeed the verbal hemisphere specialized to linear linguistic cognition.

11.1.1 Basic Facts About Bio-Photons

Alexander Gurwitsch discovered bio-photons as early as 1923 and called the phenomenon "mitotic radiation". Fritz Popp is one of those who have continued the pioneering work with bio-photons [I72, I83]. Also Roeland van Wijk [J72] shoud be mentioned as one of the many people involved. Recently the possible fundamental role of bio-photons in neuroscience has been realized.

To get a first quantitative grasp of bio-photons one can look at `http://en.wikipedia.org/wiki/Biophotons` [I7]. Ultraweak emissions of visible and also UV light from living matter. Spectrum looks continuous. Intensity (power per unit area) is 10^{-13} to 10^{-10} W/m^2. The intensity of solar radiation is 1.361 kW/m^2 and stronger by 13-16 orders of magnitude. The intensity of bio-photons is however much above the intensity of thermal radiation at energies of visible and UV photons.

In order to obtain a more biological perspective one can look for the intensity in the natural length and time scales of neuron. 2 eV is the energy of red visible photon. Using the relationship $J = 6.4 \times 10^{28}$ eV one obtains that if all bio-photons were photons with energy of 2 eV, there would be about 3.2 bio-photons per area of μm^2 characterizing cell nucleus during period of 1 ms defining characteristic time scale of neuronal firing. This raises the question whether bio-photons might be relevant for neural firing.

Chemi-oxidation via oxidative stress by reactive oxygen species (ROS) and/or catalysis by enzymes (peroxidase, oxygenase) has been suggested as a source of bio-photons [I7, I58]. The excitation of biomolecule to triplet (spin 1) state would decay via the emission of bio-photons.

Evidence has been given that bio-photons represent coherent radiation [I70, I37]. For instance, the distribution for bio-photon number for given energy is nearer to Poissonian distribution characterizing coherent state of photons (technically a state, which is an eigenstate of annihilation operator for photon of given energy and quantum analog of classical state in which it makes sense to assign classical field to the state). The coherence time from photon counts is much longer than the estimate 10^{-13} seconds based on standard sources. Time scale of at least second is nearer to reality. Also delayed luminescence (see `http://tinyurl.com/ycl75l5g`) of bio-photons [I37] as a respose to a stimulation of system by visible photons reflects long range temporal correlations and not expected for incoherent radiation. Instead of exponential decay hyperbolic power low type decay takes place. The underlying reason is not well-understood.

The coherence is not easy to understand if chemi-oxidation is the source of bio-photons although it could quite well correlate with the production of bio-photons. The coherence and empirical findings made already by Gurwitsch have inspired the proposal that bio-photons could play an important role in control and communications in living matter. The attitudes of mainstream are very negative to proposals of this kind as the Wikipedia article (see `http://tinyurl.com/yaey7ovw`) [I7] illustrates. Recently the situation have been changing and reports supporting the existence of non-chemical communications (see `http://tinyurl.com/abk828g`) between cell cultures having no physical contact are emerging [I25].

One can raise a long list of questions about bio-photons.

1. What is the actual nature of bio-photons? If bio-photons are not primary entities (contrary to what is usually believed), what is behind bio-photons? Could bio-photons be decay products of something more fundamental and perhaps new from the perspective of recent day

physics? If bio-photons are fundamental entities responsible for control and communication, the extreme weakness of their intensity becomes a problem. The idea about bio-photons as leakage of more fundamental entities could allow even metabolic role for the these entities.

2. How bio-photons are produced? The proposed mechanism based on oxidative stress does not explain coherence nor the reported communication and control function.

3. How do bio-photons or more fundamental entities relate to biology in general and specifically to metabolism, to neuroscience, to certain findings of Gariaev's group [I55], to Becker's DC currents [J24] and the related TGD inspired model discussed in [L12]? Could bio-photons relate to vision and imagination? Bischof [J101] and Bokkon *et al* [J25, J37, J87, J38, J86] have made several proposals in this respect. What is behind the correlation between EEG and bio-photons (for which multiple sources of evidence exist - [J31, J61, J58] - or that between the changes in bio-photon emission in meditative [J124] and qigong practices [J57, J48, J41, J53]? What about remote mental interactions, which are natural and ubiquitous if TGD-inspired biology is accepted: could bio-photons or more fundamental entities provide a control and communication tool?

The following considerations are inspired by a collection of mostly recent articles collected through Pubmed and the Qigong and Energy Medicine Database (see `http://tinyurl.com/ybyyns3k`) (`http://www.qigonginstitute.org/html/database.php`, [J14]). The purpose is to build a more detailed view about bio-photons relying on ideas represented already earlier [K60, K86].

The basic vision involves some new elements: bio-photons are decay results of dark photons, which are the fundamental objects. Dark photons play a key role in non-destructive reading of sensory/cognitive/memory representations by interaction free measurements. Besides dark photons and also dark phonons could be involved in interaction free meaurements and could be behind imagination resp. internal speech. Hence the notion of biophonons deserves a serious consideration. Dark photons and maybe also dark phonons would be generated by the memory reading mechanism automatically as a kind of echo and could yield virtual sensory input allowing to test whether sensory representation is realistic. Also copies of memories would be produced automatically by the echo mechanism: this could explain after-images and serve as a basic mechanism of learning. Dark photons could also serve communication and control purposes and define metabolic energy, making possible remote metabolism by what I have called quantum credit card mechanism. The energy range of biophotons corresponds to visible and UV range so that they are optimal for biochemical control by inducing molecular transitions.

11.1.2   Basic Ideas Of TGD Based Model Of Bio-Photons

The following list summarizes the key TGD inspired ideas about bio-photons.

1. *Identification of elementary particles microscopically.*

   Quantum antenna hypothesis suggests that bio-photons are associated with topological light rays - "massless extremals" (MEs, topological light rays [K79]). Biophotons - in fact, all elementary particles - are identified as pairs of wormhole contacts with wormhole contacts connecting two space-time sheets in CP_2 directions. The two space-time sheets would be most naturally ME and magnetic flux quantum (tube or sheet). These details do not matter much for applications.

2. *Identification of bio-photons as decay products of dark photons.*

   In TGD Universe bio-photons would be ordinary photons resulting from the transformation of dark large $\hbar_{eff} = n \times \hbar$ low frequency (f_l) photons to ordinary photons with high frequency (f_h). In the original form I proposed (f_l, f_h) pairing as what I called scaling law of homeopathy [K53], and later realized the connection with the hypothesis about hierarchy of Planck constants. This transition would transform low frequency dark photons with E= $h_{eff} \times f_l$ to ordinary photons with E= $h \times f_h$ ("l" is for "low" and "h" is for "high"). The outcome could be observed as bio-photons.

Any system having field body with parts having large $\hbar_{eff}$ can generate dark photons in turn decaying to bio-photons or dark photons with smaller value of $\hbar_{eff}$. Decay cascade decreasing $\hbar_{eff}$ down to $\hbar$ is the most general option and the integers n in $\hbar_{eff}(k)/\hbar = n(k)$ are factors of $n(1)$. This is a strong number theoretical prediction. The longest possible decay sequence to ordinary photons would factorize the integer $n = \hbar_{eff}/\hbar$ so that this kind of process might also have number theoretical meaning.

The low intensity of bio-photons suggests that the rate for the transformation of ordinary to dark is very low and/or that the density of charged particles (say ions of cyclotron BE condensate) generating dark photons is very low. Given a quantitative model for the mechanism one could estimate the rate for the transformation of ordinary photons to bio-photons. Gariaev's experiment [I55] yielding radio wave photons (interpreted as dark photons) from incoming laser light beam irradiating DNA sample could help to estimate the transformation rates as function of h: the most naive guess inspired by scaling argument is $1/h_{eff}$ dependence for given photon energy. DNA would induce energy conserving transformation of ordinary laser photons to long wave length dark photons with the same energy. A possible mechanism is modulation of the beam by radio wave frequency.

The crucial parameter is the magnitude for the $f_l \to f_h$ transition amplitude. Dimensional analysis suggests that the rate $\Gamma(f_l \to f_h)$ is proportional to f_l. This would give very slow rate for ELF frequencies so that the intensity of bio-photons would be very low l for a given intensity of dark photons.

The intensity of dark photons could be rather high. Gariaev reported the transformation of laser light to radio waves in scattering from DNA in rather wide range of frequencies [I55]. These photons had biological effects on remote target (stimulation of growth of potatoes). If radio frequency photons are dark photons with visible energies they could have provided metabolic energy for high enough intensity. The role of controller is also possible. Dark photons could be also used to read memory representation in non-destructive way by interaction free measurements so that dark photons would be fundamental from the point of view of cognition.

The value of not only h_{gr} but also that of h_{eff} at magnetic flux tubes could be proportional to the mass of charged particle populating the flux tube in question. Flux tubes would distill the molecules to separate flux tubes. Cyclotron energy scale would be universal and does not depend on the mass of charged particle: therefore bio-photons would have universal energy spectrum in the range of molecular excitation energies.

3. *Possible connection with negentropic entanglement.*

   The connection of dark photons with negentropic entanglement is not well understood but highly suggestive. One can imagine at least three reasons for the connection, which are not necessarily exclusive.

   (a) If the braiding (geometric entanglement!) of magnetic flux tubes carrying dark matter and dark photons (!) serves as a correlate for negentropic entanglement, braided collections of flux tubes define negentropically entangled systems serving as negentropy sources. This fits nicely with DNA as topological quantum computer vision [K5] and with the vision about various representations (sensory, motor, memory,..) [L15]).

   (b) Dark photon with $\hbar_{eff} = n \times \hbar$ with frequency f_l can be said to contain $n$ordinary photons with frequency f_l. Could these analogs of ordinary photons be negentropically entangled?

   (c) An alternative view is that dark photons are necessary for generating quantum coherence and negentropic entanglement in long length scales. This option is consistent with the first two options.

   Note: Topologically dark photons correspond to the n sheets of n-fold covering of space-time sheet assignable to n-furcation reflecting the failure of the strict determinism of Kähler action for preferred extremals. One might even ask whether dark photon with energy E could be seen as space-time correlate of Bose-Einstein condensate of photons with energy E/n!

4. *Some signatures of bio-photons in TGD Universe.*

The simultaneous presence of frequencies f_h and f_l is the basic signature of the proposed mechanism. Cyril Smith [J27] has done a lot of work with this kind of connection and claims that $f_l \leftrightarrow f_h$ transformations (interpreted as transformations between dark and bio-photons in TGD framework) occur in living matter. His interpretation is completely different. Smith mentions the frequency ratio $f_h/f_l = 2 \times 10^{11}$ as very special one. For $\hbar_{eff}/hbar = 2 \times 10^{11}$ radiation with $l_l = 2.56$ kHz would correspond visible photon with $\lambda = .6$ μm at the red end of the spectrum.

Assuming that bio-photons indeed appear in TGD Universe, the first predicted signature is a correlation between fluctuations in EEG power and the ultraweak emission of visible photons from brain identified as particular kind of bio-photons. This kind of correlation has been observed [J31] but visible photons emerge from right hemisphere [J58].

(a) Could this mean that right brain and left hemisphere emit dark photons in different energy ranges: one possibility is that left hemisphere emits infrared photons above the thermal energy. The photons would have energies above the Josephson energy $E_J = 2eV_{rest} = .12$ eV in case of Cooper pairs of electrons. Here $V_{rest} \simeq .06$ V denotes the membrane resting potential are possible infrared analogs of bio-photons.

(b) The idea that dark photons correspond to imagination and dark phonons to internal speech in turn would suggest that left brain as brain hemisphere responsible for internal speech operates with dark phonons rather than dark photons. Right hemisphere being specialized to spatial thinking would favor dark photons.

Second signature are long range temporal correlations reflecting the origin of bio-photons. These correlations are observed for bio-photons as delayed luminescence [I37] and the sequel presents a model for the correlations based on dark photons explaining hyperbolic decay law and suggesting a totally unexpected connection with zeros of Riemann zeta.

11.1.3   Are Biophonons Also Predicted?

It came as a surprise that a general model for the non-destructive reading of memory mental images and their time reversals (interpreted as predictions of the future based on interaction free measurement) in principle allows the use of not only dark photons, but also *dark phonons* in the reading process. The mechanisms of imagination and internal speech could emerge from the general structure of quantum jump and model for self representation based on negentropic entanglement.

The identification of bio-photons as decay products of dark photons suggests strongly that biophonons also result as decay products of dark phonons. Internal speech could be one manifestation of the transformation of dark phonons to ordinary ones. This transformation could also appear as a dissipative leakage phenomenon.

As a pleasant surprise came the realization that there is a poorly understood phenomenon of this kind known as Taos hum [I93]. The patient suffering from it hears an unpleasant humming sound reflecting the properties of the acoustic environment but which does not generate any response in microphones. Nevertheless neurophysiological correlates for hearing the Taos hum are observed.

Taos hum is experienced only after and before sunset. The electric "static" (electrical noise in shortwave radio receivers) beginning after sunset and believed to have a biological origin has been proposed to at least correlate with this phenomenon. A natural interpretation would be that when vision is not a possible communication tool anymore, dark photons or dark phonons propagating along ME-flux tube pairs are used for communications. Since living matter is full of electrets dark photons or phonons can give rise to the static.

Several options can be considered: dark signal could propagate from the source to receiver as dark photons or phonons along ME-magnetic flux tube pair, continue by travelling along ME-flux tube pair parallel to the auditory pathway down to the ear as dark photons or phonons and transform then to ordinary phonons generating the experience. The most conservative option consistent with the earlier proposal that the distinction between right and left hemispheres relates

to the wave length range of dark photons (bio-photons in left hemisphere would be in infrared) [K30].

It seems that Taos hum is experienced in a pathological situation: a possible interpretation is that the leakage of dark phonons to bio-phonons is too strong and leads to the experience. Also the electromagnetic component of the patient's immune system could fail and negative energy dark photon signals could suck metabolic energy from the patient.

I will consider a slightly modified briefer version of a model that I developed for Taos hum for more than a decade ago as evidence for the notion of magnetic body [K60] (sensory magnetic canvas was the term that I used at that time). In this model Taos hum was interpreted as a phenomenon analogous to microwave hearing. At the end I will consider variants of the model involving dark photons and/or dark photons.

The appendix of the book gives a summary about basic concepts of TGD with illustrations. Pdf representation of same files serving as a kind of glossary can be found at `http://tgdtheory.fi/tgdglossary.pdf` [L18].

11.2 Bio-Photons In TGD Universe

I have discussed already earlier the identification of bio-photons in TGD framework [K23, K86].

11.2.1 The Origin Of Bio-Photons In Standard Physics Framework

The are several proposals for the source of bio-photons: for instance cell membrane [I52], DNA [I70], mitochondria [I75], linear molecules [I105], microtubules are proposed as sources of bio-photons. The existence of several sources conforms with the universality of production mechanism.

1. Biophotons seem to be emitted under stress [I104]. It has been proposed that bio-photons arise as a product of redox reactions of free radicals [I7, I58]. The hypothesis is motivated by the correlation between bio-photon counts and doses of reactive oxygen and nitrogen species but does not explain in any obvious manner the coherence of bio-photons. The proposed production mechanism is that a biomolecule is excited to a triplet state (spin 1) and releases photon as it returns to the ground state. Laser like behavior would be required in order to achieve the coherence. The correlation of bio-photon production with ROS can however have alternative explanations.

2. A model for bio-photon production based on non-linear polarizable double layers obeying Maxwell's ED: cell membrane is proposed [J86]. Destructive interference between incoming and reflected wave leaving a wave confined inside double layered structure.

11.2.2 The Origin Of Bio-Photons In TGD Universe

Dark photons decaying to bio-photons could be produced by many systems - even non-living systems. Therefore the production mechanism of bio-photons would be universal and there would be several dominating production mechanisms for bio-photons. One test for this is to check whether water and quartz crystals produce bio-photons (the claimed health effects of quartz crystal might be real and relate to dark photons).

In the framework of standard biology one would try to identify biochemical mechanisms for the production of bio-photons. The coherence of bio-photons however suggests that something totally new is involved. Just the assumption that something genuinely new is involved of course sounds rather outlandish unless one has a concrete proposal for what this new is and unless this something new is able to solve other puzzles.

Do dark photons give rise to biophotons?

The basic philosophy in what follows will be as following. In computer world decomposition to hardware and software is very useful. In biology this division could mean that biochemistry describes dynamical hardware and also the mechanisms modifying it. Electromagnetic fields in TGD sense, dark photons, magnetic body, topological quantum computation, communications

and control by dark photons would correspond to software. If this division is real, one might have rather satisfactory description of the software without even mentioning biochemistry. "Biology is governed by symbolic dynamics" is other manner to state the idea: to predict the behavior of priest all that one needs to know that he/she is a priest. One could never predict the behavior of priest from biochemistry and Newton's laws but single word "priest" associated with his person allows this. The basic justification for this separation between software and hardware (biochemistry) would come from the identification in terms of dark matter having now direct interactions with ordinary matter (in the sense that particles with different value of $\hbar_{eff}$ cannot appear in interaction vertices.

1. In TGD framework the counterpart of confinement inside double layered structure in polarizable media proposed as a model for bio-photons [J86] is confinement of photons inside topological light rays (MEs) acting like wave guides. Mechanism can be said to be gravitational since MEs are not only extremely non-linear structure but as space-time quanta also gravitationally non-trivial. The deviations of TGD from Maxwell's electrodynamics (MED) are important and come from induced field concept implying also topological field quantization. For instance, MEs are analogous to wave guides and have no counterpart in MED. MEs can carry non-vanishing light-like currents not possible in MED. MEs mediate precisely targeted signals propagating with light velocity without changes in their shape, to only single direction. Therefore MEs are ideal for communication and control. Topological field quantization makes space-time topology in various scales a key player also in biology. This leads to the notion of magnetic body and also the notion of electric flux quanta such as cell membrane.

2. In TGD Universe the large value of $\hbar_{eff}$ provides a general explanation for macroscopic quantum coherence. This allows several sources of bio-photons resulting when dark photon transforms to ordinary photon of same energy.

   - Dark photons could be absorbed and emitted in cyclotron transitions at magnetic flux tubes. Dark photons could be Josephson photons from a Josephson junction formed by the lipid layers of cell membrane. The minimal energy for the Josephson photon assignable to electronic Cooper pair is $E = 2eV_{rest} = .12$ eV for electronic Cooper pair and $V_{rest} = .06$ eV and is above thermal threshold. More generally, the spectrum of dark photons would be a combination of cyclotron spectrum and Josephson spectrum assignable to cell membrane [K44]. Frequencies would come as sums of harmonics of cyclotron frequency for a given bosonic ion or Cooper pair of fermionic ions and harmonics Josephson frequency.

   - The variation of the membrane potential induces a modulation of Josephson photon frequencies $f_J = ZeV$. This suggests that frequency modulation defines the fundamental information representation. This brings in mind whale's song - maybe mathematically very similar to human speech (as hearing in as slowed down version reveals) - in various time scales!

   - Huping Hu has observed that dipole magnetic interaction between protons with distance of 10 nm corresponds to energy scale in EEG frequency scale [J85] [K30]. Large $\hbar_{eff}$ could raise the energy to visible range. The cyclotron transitions assignable to the pairs of dark protons forming analogs of Cooper pairs could generate dark photons with EEG frequency and cytochrome oxidase could catalyse the energy metabolism providing them energy.

   One can raise several questions about dark photons and bio-photons.

1. How are dark photons generated? Gariaev's experiments [I55] suggest that at least DNA induces transformation of ordinary photons to dark photons with much lower frequency. Could amplitude modulation of f_h signal by f_l signal provide a mechanism producing $\hbar_{eff} = f_h/f_l$ dark photons decaying to bunches of ordinary f_l photons or to ordinary f_h photons? Resonance condition requires integer valued frequency ratio and in principle this could serve

as a test. In many experiments, say the pioneering experiments of Blackman and others (see for instance [J28]), this kind of modulation is involved. If this mechanism really works it provides a tool for producing dark photons: this has an obvious technological potential.

2. How would reactive oxygen species induce $\hbar_{eff} \to \hbar$ transitions inducing a loss of coherence? The process should be the inverse for the generation of dark photons. Analog of induced emission: presence of ordinary photons of same energy in state would increase the rate for the transition $\hbar_{eff} \to \hbar$. What is the reverse of amplitude modulation? Small ripples in a slowly varying wave. Amplitude modulation with frequency much higher than modulated frequency. Are these two descriptions equivalent?

3. What is the connection with quantum antenna hypothesis [K79] ? Pairs of MEs and magnetic flux tubes giving rise to structures parallel to linear structures populating biosystems (axons, microtubules, DNA, linear molecules, etc) could be involved. Larger space-time sheet would induce a modulation by lower frequency defined by its scale. A hierarchy of amplitude modulations would be the outcome.

Has the decay of dark photons to visible photons observed in astrophysical scales?

There is an interesting news providing new light to the puzzles of dark matter in New Scientist (see `http://tinyurl.com/y9r65xnh`). It has been found that Universe is too bright. There are too many high energy UV photons in the spectrum. The model calculations suggest also that this too high brightness has emerged lately, and was not present in the early universe. The intergalactic space contains more neutral hydrogen and thus also more ionized hydrogen as thought previously and it was hoped that the ionized hydrogen could explain the too high brightness. It is now however clear that 5 times more ionized hydrogen would be required than theory allows accepting the experimental data.

The question is whether dark matter could explain the anomaly.

1. The usual dark matter candidates have by definition extremely weak interactions - not only with ordinary matter and also with dark matter. Therefore it is not easy to explain the finding in terms of ordinary dark matter. The idea about dark matter as remnant from the early cosmology does not fit naturally with the finding that the surplus UV radiation does not seem to be present in the early Universe.

2. In TGD dark matter is ordinary matter with large $h_{eff} = n \times h$ and has just the ordinary interactions with itself but no direct interactions with visible matter. Thus these interactions produce dark radiation with visible and UV energies but with probably much lower frequencies (from $E = h_{eff}f$). The energy preserving transformations of dark photons to ordinary ones are an obvious candidate for explaining the surprlus UV light.

3. These transitions are fundamental in TGD inspired model of quantum biology. Biophotons are in visible and UV range and identified as decay products of dark photons in living matter. The fact that the surplus has appeared recently would conform with the idea that higher levels of dark matter hierarchy have also appeared lately. Could the appearance of UV photons relate to the generation of dark matter responsible for the evolution of life? And could the surplus ionization of hydrogen also relate to this? Ionization is indeed one of the basic characteristics of living matter and makes possible charge separation [L23], which is also a crucial element of TGD inspired quantum biology [K90]

11.2.3 Biophotons, Dissipation, And De-Coherence

1. By above proposal the yield of bio-photons would be a leakage process. The transformation of dark photons to ordinary or dark photons with smaller $\hbar_{eff}$ means reduction of coherence length of order wave length by the ratio of final and initial effective Planck constants. The process leading to visible photons leads to a coherence length which is fraction of micron. Therefore also dissipative effect is in question. The ordered energy of dark photon BE condensate transforms to less ordered energy of ordinary photons.

The process is expected to reflect the long scale coherence of dark photons. This could resolve the basic objection against the observation of delayed luminescence for which time scale should be of order 10^{-13} seconds for standard value of $\hbar$. Scaling of $\hbar$ to $\hbar_{eff}$ can increase this time scale even to seconds if not longer time scales.

In the simplest mode the intensity of bio-photons is proportional to the intensity of dark photons proportional to the modulus squared for dark photon complex order parameter assignable to a coherent state of dark photons. Also other than coherent states are possible: for instance, Popp *et al* have suggested so called squeezed states (see `http://tinyurl.com/y9qbh6nr`) [I73].

2. Cancer could be understood as a disorder in which $\hbar_{eff}$ of part of magnetic body is reduced to smaller value and eventually to its ordinary value of $\hbar$ so that long range coherence is lost. If dark photons have energy of visible photons, basic coherent units have size of cell and one obtains "selfish cells" [I85].

3. Redox reactions, ROS and RNS induce loss of coherence by inducing process reducing $\hbar_{eff}$ and production of bio-photons: perhaps by the inverse of amplitude modulation which might generate dark photons. These reactions could have also a useful role in hardware development. Kind of etching of 4-D brain as a representation of self (modification of synaptic connections for instance) might be the basic function and necessarily involves dissipation.

11.2.4   What Is The Origin Of The Hyperbolic Decay Law?

The basic question concerns the origin of the hyperbolic decay law. It is not actually clear whether this law as anything to do with genuine decay or whether it reflects the behavior of complex order parameter of dark photons as a function of time. The latter interpretation is supported by the following argument.

The intensity decays slowly being in the first approximation of form $I(t) = I(0)/(1 + \lambda t)$: also hyperbolic waves of form $I_0 sin(log(1 + (t/t_0)))$ have been reported. The most general form for the intensity is

$$I(t) \quad = \quad I(0) \times exp(\lambda u) \ , \tag{11.2.1}$$

where $\lambda 1 + iy$ is complex parameter and $u = log(1 + \lambda t)$ is the analog of time coordinate defined as logarithm of the shifted and normalized dimensionless time coordinate $T = (t + t_0)/t_0$. Fractal power law $I \propto T^\alpha$ approaching for large values of t to $I(t) = t^\alpha$ would be in question.

In zero energy ontology (ZEO) this kind of behavior can be related to Lorentz invariance.

1. The boundary of CD corresponds to light-cone boundary with light-like coordinate. For irreducible representations of Lorentz group the wave functions at light-cone boundary $t = r$ ($c = 1$ in the units used) behave as r^α. The appearance of this coordinate might be due to the fact that dark photons travelling with light-velocity are involved.

2. For hyperboloids $t^2 - r^2 = a_0^2$ one would have wave functions behaving as

$$A_y(t) \quad = \quad A_0 \times u^s \ , \quad s = -1/2 + iy \ , \quad u = \left(\frac{t^2 - a_0^2}{a_0^2}\right)^{1/2} \ . \tag{11.2.2}$$

The intensity would be of the form

$$I_y \quad = \quad \frac{A_0^2}{u} \tag{11.2.3}$$

approaching the hyperbolic form for $t \gg a_0$. For $a_0 = 0$ one obtains exact power law behavior $I \propto t^{-1}$.

3. Oscillatory behavior is obtained if one has superposition of two waves of this kind with different values of y:

$$A = cos(\phi)A_{y_1} + sin(\phi)A_{y_2} \tag{11.2.4}$$

giving

$$I = \frac{1 + sin(\phi_1 + \phi_2) \times cos[(y_1 - y_2)log(u)]}{u} \tag{11.2.5}$$

approaching hyperbolic decay law for $t >> a_0$ and diverging for $t = a_0$. Linear combinations $\sum a_n A_{y_n}$ are also possible.

What is intriguing that the form of the complex parameter s is same as for the zeros of Riemann zeta.

1. There are several reasons to believe that the zeros of Riemann zeta might play fundamental role as "scaling momenta" in TGD framework [K100]. For instance, if the spectrum of wave vectors associated with the zeros of zeta is discrete and consists of logarithms of integers so that the zeros of Zeta define quasilattice, Riemann hypothesis holds true [K100]. Furthermore, discrete spectrum for the zeros is strongly favored by number theoretical considerations since it gives hopes about p-adic algebraic continuation of the integral by reducing it to sum for both zeros of zeta and for the Fourier transform.

2. The quantization of spectrum for the distribution defined by zeros of Zeta means that the spectrum of "momenta" is integer valued in suitable units. In the recent case the momenta correspond to values of the radial coordinate r so that only the integer values $r = nr_0$ are possible. The interpretation would be in terms of discretization of the radial coordinate r and also of time. This is just what number theoretic vision suggests and the notion of p-adic manifold (see appendix of the book) requires both at real and p-adic side.

3. This argument would suggest that hyperbolic scaling law at light-cone boundary actually corresponds to a distribution

$$A(u) = \sum_y A_y(u) \ , \ \ u = \frac{t}{t_0} \ \ .$$

localized to the values $u = t/t_0 = r/r_0 = n$. This implies automatically infinite number of interefence terms in the intensity $I(u) = |A(u)|^2$ and the comparison of $I(t/t_0)$ with the experimentally determined intensity of bio-photons serves as a killer test for the proposal since only one parameter - t_0 determining the scale - appears in the model.

11.3   Do Dark Photons Transform To Bio-Photons?

The following text is based on comments about the article *Quantum and Holistic Response of Human Skin to H_2O_2 Stimulation* by R. P. Bajpai, A. Rastrog and A. Popp to be published in Journal of Nonlocality (JNL).

The notion of bio-photon is now well-established and there is a lot of activity in this field. It is becoming clear that bio-photons might be highly relevant for brain functions as the correlations between fluctuations associated bio-photon emission and fluctuations of EEG. Some examples of experimental work relevant to what follows are bio-photon emission from hand [I132], the effect of hydrogen peroxide H_2O_2 on bio-photon emission from radish root cells [I131], and delayed luminescence of leaves [I133].

R. Bajpai has discussed a squeezed state description of spectral decompositions of a bio-photon signal [I134, I36]. This proposal is highly interesting from TGD point of view, which relies on the notion magnetic body carrying dark matter as large $h_{eff} = n \times h$ phases identified as dark matter. Magnetic body would control living matter by its "motor actions" such as changing the thickness of a flux tube carrying monopole flux so that the strength of magnetic field and therefore cyclotron frequency changes. Dark cyclotron photons could transform to ordinary photons with the same energy identified as bio-photons and bio-photons could be seen as a kind of leakage.

Squeezed photon emission relies on a modification of harmonic oscillator mass or frequency or both meaning that the original vacuum state becomes many-photon state. The fact that the cyclotron states of charged dark matter at magnetic flux quanta indeed are essentially harmonic oscillator states suggests that the "motor action" of the magnetic body consisting of the change of flux tube thickness induces the emission of squeezed dark photons with wavelengths scaled up by $h_{eff}/h = n$ in turn decaying to bio-photons with a universal energy spectrum if the conjecture equating h_{eff} with gravitational Planck constant $\hbar_{gr} = GMm/v_0$ introduced by Nottale: $h_{eff} = h_{gr}$ indeed implies that the dark photon cyclotron spectrum does not depend on the mass of the charged particle.

This model would explain the coherence of bio-photon emission in macroscopic and macro-temporal scales. Bio-photon emission would reflect the decay of dark photons to ordinary photons identified as bio-photons. Hyperbolic decay law corresponds to exponential decay law with respect to logarithmic of time variable bringing in mind renormalization group: this replacement could reflect the fact that a scaling of causal diamond (CD) is identifiable as the geometric counterpart of subjective time in TGD inspired theory of consciousness.

11.3.1 Basic Ideas

In the following I try to summarize what I have understood about bio-photon emission.

1. Bio-photon emission is induced by some external stimulus, which can be light or stress of some kind, say chemical stress such as hydrogen peroxide (H_2O_2) stimulation. The signal is ultra-weak and broadband so that spectroscopy is difficult. The signal is analyzed in time domain by dividing the time interval into pieces with duration say 3 minutes and deducing photon number distribution, average photon number, and variance for each interval. The variation of the interval length is used to deduce whether signal can be modelled semi-classically as being produced by independent transitions of molecules or whether "quantum entity" is responsible for the signal. The average signal strength is constant but there are fluctuations inside bins.

2. The interpretation proposed in the article is in terms of squeezed photons: this state has minimum quantum un-certainty - that is the product $\Delta x \Delta p$ for canonically conjugate variables associated with the signal has the smallest possible value consistent with Uncertainty Principle. I understand that there is a constant average signal plus a slowly decaying tail representing the reaction of "quantum entity". The temporal coherence in long time scales is one motivation for "quantum".

3. Bio-photon signal would be produced by a decaying squeezed state with long lifetime and with hyperbolic rather than exponential time dependence. Similar model applies also to bio-photon signal generated by a dose of light: according to the article these two signals have 3 identical squeezing parameters. A further parameter having interpretation as a strength of response is not universal. Also delayed luminescence gives rise to similar signal. The suggestion is that in all cases some "quantum entity" reacts to the stimulus: chemical stress in the case of H_2O_2 stimulation.

4. The alternative interpretation based on semiclassical model assuming that statistically independent molecular transitions produce the signal does not allow to understand the signal: for instance an exponential decay rate is predicted and the response should reflect the molecular transitions involved. Also constant value of average signal strength is difficult to understand semi-classically.

There is a nice article about squeezed light at `http://tinyurl.com/y97r7eda` [B8].

1. The mathematics behind the notion is that of harmonic oscillator with slowly varying mass and frequency parameters. The vacuum state of oscillator is one example of squeezed state with minimum momentum position uncertainty (for photons photon number-phase uncertainty). Coherent state of oscillator obtained by applying resonant driving force is second example of squeezed state.

2. A general squeezed state is characterized by complex squeezing parameter $R = e^r$, and phase angle ϕ mentioned also in the article. Besides this there is angle θ telling the rotation made for the counterpart of spatial coordinate before squeezing so that squeezing is maximal for θ. To my understanding θ and ϕ describe essentially the same thing but I am not sure.

3. For amplitude (phase) squeezed state the position (momentum) uncertainty is minimized below that for harmonic oscillator vacuum state but Uncertainty Principle forces the increase of width of the distribution for phase. Now these canonically conjugate variables correspond to photon number and phase angle analogous to the rotation angle of harmonic oscillator rotating in position-momentum plane.

4. There is also a parameter called displacement (α): this parameter characterizes the displacement of the position of harmonic oscillator vacuum occurring already for harmonic oscillator under resonant oscillator force for which potential is linear on position and momentum: the stronger the force, the larger the displacement. Unlike (r, θ, ϕ) α does not seem to be universal. The value of the displacement $|\alpha|$ would naturally characterize the strength of the stimulus modelled as a resonant oscillatory external force.

5. Squeezing can be described formally in terms of an exponential of a squeezing operator analogous to an oscillator Hamiltonian. Squeezed state is defined by its exponent giving rise to a formal time evolution to be not confused to real time evolution of squeezed state which can be created by a sudden scaling of the parameters of oscillator Hamiltonian preserving the area in position-momentum plane.

   The peculiar feature of squeezed light is that in frequency domain photons appear as pairs in the sense that the state is superposition of states with even photon number.

6. Time dependent parameters in oscillator Hamiltonian is one manner to produce squeezing (`http://tinyurl.com/y89mvsnu`. The vacuum state for harmonic oscillator becomes squeezed state when (say) the frequency of the oscillator becomes time dependent. In the simplest situation the oscillator frequency could suddenly change to some other value. I have an impression that this kind of sudden change of oscillator Hamiltonian induced by the external stimulus is assumed to make vacuum state a squeezed state.

   With respect to new oscillator Hamiltonian the vacuum state is squeezed state that is superposition of many-photon states with even photon number. Squeezing in the most general case is time-dependent symplectic transformation preserving the area in position-momentum plane and as a special case one can have time dependent modulation of harmonic oscillator mass and frequency, now photon frequency. The modulation would very slow as compared to photon frequency for ordinary value of Planck constant.

11.3.2 The Key Challenge

Introduction discusses also what authors of and also I see as a key problem.

1. Some mechanism must provide the energy for quantum entity so that it can generate bio-photon signal or something generating bio-photon signal. This is mentioned in introduction as the basic unsolved problem. It is not at all obvious how (and even whether!) universal energy quantum of about.5 eV and considerably below the bio-photon range beginning at about 1 eV (visible and UV).

2. Two mechanisms have been proposed: explicit and implicit. Explicit mechanism involves chains of chemical reactions of reactive oxygen species helping to gather metabolic energy to that of molecules (up conversion). The signal would reflect the chemical properties of bio-molecules in the chain involved. Implicit signal would be signal coming from quantum entity and depend on its states and evolution of the response of quantum entity to the stimulus.

3. The conclusion is that the explicit mechanism is not favored and that implicit mechanism produces squeezed state. The challenge is to identify the "quantum entity" and understand whether it provide the metabolic energy directly or helps to transform ordinary metabolic energy to that of bio-photons. Also one must understand how the "quantum entity" receives its energy - presumably from Sun too.

11.3.3   What I Did Not Understand

There were many things that I failed to understand, basically due to the lacking background knowledge about squeezing.

1. What the estimated values of r and ϕ (equivalent with θ?) are? It would be nice to have something about this in introduction. An illustration of time evolution of a squeezed state would help enormously. A brief summary of definitions of basic parameters as Appendix would help enormously non-specialist reader.

2. The oscillator Hamiltonian involves oscillator frequency. What is the value of this frequency now and how it relates to the photon frequency? Can it be equal to photon frequency for visible light or does it perhaps correspond to the time scale for oscillation in squeezing (phase rotation). Or can this frequency be interpreted in terms of amplitude modulation.

   I saw in Wikipedia an example in which the variation of phase uncertainty corresponds to a period of 10-100 ms. This is bio-logical time scale range. It would be nice to have a comment about the value and possible origin of the slow time scale associated with the squeezing since it would naturally relate to the time scale of macro-temporal quantum coherence.

11.3.4   TGD Inspired Comments

Some TGD inspired comments are in order since the squeezed light would be very naturally be induced by "motor actions" of magnetic body.

Do motor actions of the magnetic body induce squeezing?

1. TGD predicts a hierarchy of Planck constants $h_{eff} = n \times h$ and suggests that cyclotron frequency modulation is one of the key mechanisms in living matter. For instance, the variation of membrane potential would induce modulations of generalized Josephson frequency which is sum of difference of cyclotron frequencies and the ordinary Josephson frequency $f_J = 2eV/h_{eff}$. The modulation of the frequency and amplitude of harmonic oscillator to yield time dependent symplectic transformation is one mechanism producing slowly varying squeezing. Low frequency modulation of this kind could produce also dark photons which according to TGD inspired proposal would transform to ordinary photons with same energy identified as bio-photons.

2. In TGD framework the squeezed state would be that of dark photons with $h_{eff} = n \times h$ and much larger than ordinary Planck constant to guarantee that VLF or even ELF frequencies correspond to energies in the range of bio-photon energies ($E = h_{eff}f$). This must be taken into account when if one tries to model the situation. The large value of h_{eff} would explain the slow time scale of squeezing naturally. For the ordinary value of Planck constant the time scale of squeezing is gigantic as compared to the natural time scale assignable to visible photons (about ten femtoseconds).

3. An instantaneous change of the frequency of harmonic oscillator produces squeezed state. The change of the thickness of the magnetic flux tube would change the value of magnetic field strength (by flux conservation) and thus of cyclotron frequency $\omega = ZeB/m$. This would affect the oscillator frequency (cyclotron states can be regarded as harmonic oscillator states) so that the outcome would be squeezed state. Do "motor actions" of magnetic body induce squeezed photon states? Does magnetic body react to stimuli by changing the thickness of its flux tubes?

4. Could a phase transition changing the value of Planck constant induce a squeezed state? The answer is negative. If the scalings $x \to nx$ and $\omega \to \omega/n$ take place in the phase transition $h \to n \times h$ as has been assumed then $h \to n \times h$ respects the property of being energy eigenstate property and vacuum goes to vacuum.

The following comment is not directly related to squeezing but to possible interpretation of phase transitions changing Planck constants as singular symplectic transformations (symplectic group of $\delta M_+^4 \times CP_2$ is isometry group of "world of classical worlds" (WCW).

1. Magnetic flux is invariant under symplectic transformations defined by magnetic field for the surface over which it is taken. These symplectic transformations have nothing to do with those of phase space since they act at the level of space-time. One can still ask whether transformations analogous to basic squeezing could make sense.

2. A especially interesting choice of symplectic variables corresponds to the choice of cylindrical coordinates (ρ, ϕ). The symplectic transformation $(\rho, \phi) \to (\rho/a, a \times \phi)$ for $a = n$ would scale does the thickness of the flux tube by integer n and increase the angular range from 2π to $n \times 2\pi$. A possible interpretation is that one obtains a multi-sheeted covering by allowing the original variable ϕ to have range $n \times 2\pi$.

3. What makes this interesting is that just this kind transformation is assumed to take place in the transition $h \to h_{eff} = n \times h$ and lead to n-fold singular covering of space-time surface. Could the phase transition increasing Planck constant correspond geometrically to a singular symplectic transformation leading to n-fold covering and radial scaling at the level of space-time?

What is behind the hyperbolic decay law of the squeezed state?

One should also understand the hyperbolic decay law of the squeezed state.

1. What causes the slow hyperbolic decay of the squeezed state? Hyperbolic decay corresponds to the exponential decay $dN/d\tau = -kN + R$ but with time variable u which is logarithm of ordinary time variable: $\tau = log(1 + t/t_0)$ (note the convention $u(t = 0) = 0$). This gives decay law

$$N(t) = N(0) \times \left[1 + \frac{t}{t_0}\right]^{-k} + \frac{R}{k} \quad .$$

For $k = 1$ one obtains $x \propto 1/t$ hyperbolic behavior for large values of t. Somehow the ordinary linear time is replaced by its logarithmic variant.

2. In TGD framework the decay would correspond to the gradual decay of dark photons to ordinary photons. The decay kinetics for dark photon number N_D and bio-photon number N_B would be described by two equations:

$$\frac{dN_D}{du} = -kN_D + R \ , \ dN_B = kN_D \ , \ u = log(\frac{t}{t_0} + 1) \quad .$$

The rate for emission of bio-photons would be now

$$\frac{dN_B}{dt} = kN_D(0) \left[1 + \frac{t}{t_0}\right]^{-k} + R \quad .$$

$k = 1$ gives hyperbolic decay law. Note that the rate approaches to the rage R of dark photon production: constant background intensity of bio-photons has been indeed observed.

3. What is the mechanism replacing the time coordinate with its logarithm in the decay law? The logarithmic behavior strongly suggests a connection with a renormalization group approach relying on scaling invariance: the extension of 2-D conformal invariance so that it makes sense in 4-D context is indeed the basic symmetry of quantum TGD. Time evolution would correspond to scaling. Scale invariance implies that the logarithm of the scale appears as an evolution parameter in renormalization group evolution. Zero energy ontology would suggest that time coordinate corresponds to the scale characterizing the size of causal diamond (CD) and that time evolution for the bio-photon emission corresponds to a quasi-continuous scaling of CD.

4. In TGD inspired theory of consciousness the correspondence between subjective time and geometric time reduces basically to the identification of time evolution as subsequent scalings of CD occurring in repeated state function reductions, which would in ordinary quantum measurement theory leave the state invariant.

Where do bio-photons get their energy?

The basic problem of bio-photon scenario is the mechanism providing the metabolic energy for bio-photons. Ordinary metabolic energy quantum is around .5 eV and below visible energies.

1. In TGD the quantum entity would be magnetic body with hierarchical onion-like structure with layers, whose sizes can be even larger than that of Earth. Cyclotron frequency defines time scale and for large $h_{eff} = n \times h$ the frequency of cyclotron photons can be even in ELF range (say in EEG range). h_{eff} would thus scale up the time scale of coherent and the values of h_{eff} deduced earlier are so large that it could be measured in time scales assigned to EEG.

2. In TGD framework one can consider the possibility that cell membrane as generalized Josephson junction and in microscopic description membrane proteins acting as generalized Josephson junctions generate dark photons in visible and UV range and these in turn transform partially to ordinary photons identifiable as bio-photons. Could ordinary metabolism excite the dark cyclotron Bose-Einstein condensed (like laser in population reversed state)?

3. Or could the magnetic body associated with the bio-systems receive this energy directly from Sun: as ordinary solar photons transform to dark photons at magnetic body. I have considered a mechanism for creating CDs (not causal diamonds now but coherence regions of water of size of order micrometer suggested by Vitiello and Del Giudice (`http://tinyurl.com/yagy3fcu`) [I46]). Inside CDs were water molecules would be excited to energies slightly below the bond energies in the exclusion zones (EZs): the difference would be just the metabolic energy quantum .5 eV.

   Metabolic energy quanta could generate EZs of size of large neuron by splitting O-H bonds and giving rise to $H_3/2O$ stoichiometry inside EZs. My own crazy proposal is that the UV energy about 12 eV comes directly from Sun as ordinary photons and travels as dark photons along flux tubes of magnetic body to the organism and partially transform to bio-photons. This model can be generalized to include dark photons covering entire spectrum of bio-photons (there is an argument predicting that the spectrum of dark photons is universal and that of bio-hotons). A precise model for energy balance might help to conclude that "quantum entity" providing additional metabolic energy must be there.

   For year or two ago there was a discussion in Journal of Non-Locality about people claimed to be able to receive their metabolic energy from solar radiation and just for fun I considered a model based on dark photons and involving same mechanism as appears in metabolism. I also remember of having seen years ago a paper about problems in attempts to understand energy balance in brain but do not remember more about this.

Squeezing and entanglement

A very interesting variant of squeezed state mentioned in `http://tinyurl.com/y97r7eda` [B8] is two-photon squeezed state. In this state the amplitude to begin with is product of two vacua,

which is unentangled state. The other vacuum is squeezed up in position by R and other one down by $1/R$. This produces entangled state, which is highly interesting bio-logically: could this entangle "quantum entity" and the receiver of the radiation? Is it possible to interpret the findings about bio-photons in terms of two-photon squeezing?

11.4 How Could Dark Photons And Phonons Relate To Consciousness?

One of the basic objections against the identification of moment of consciousness as quantum jump is that contents of consciousness corresponds always to change. How it is possible to code anything about the states of the world if this is the case? For instance, how conscious entity can construct a self model which by definition should correspond to something which is approximately invariant in quantum jump sequences? Negentropically entangled subsystems indeed can be parts of the state approximately invariant under dynamics dictated by Negentropy Maximization Principle (NMP) [K70].

The manner to circumvent the objection comes from the notion of interaction free measurement: the conscious information about invariant part of system, say self model, could be obtained by interaction free measurement, which involves state function which leads the incoming photons to interaction free state. This information would be obtained as sequences of bits and might be correspond to declarative, verbal memories rather than direct sensory experiences.

11.4.1 What Does Bomb Testing Have To Do With Cognition And Consciousness?

Dark photons decaying to bio-photons could be involved with the basic cognitive processes like memory recall involving interaction free measurement. At the ideal limit the photon which interacts with a subsystem representingbit of memory mental image suffers state function reduction to a path at which it does not interact with the memory system in the usual sense. Hence memory mental image is not affected at all at this limit. The following model for memory recall is discussed in the article "A Vision about Quantum Jump as a Universal Cognitive Process" (see `http://tinyurl.com/yc46pq86`) [L13]

1. The bomb testing problem of Elitzur and Vaidman gives a nice concrete description of what happens in interaction free measurement, see `http://tinyurl.com/kx2jsyu` [B3] for illustration of the system considered.

   The challenge is to find whether the bomb is dud or not. Bomb explodes if it receives photon with given energy. The simplest test would explode all bombs. Interaction free measurement allows to make test by destroying only small number of bombs and at idealized limit no bombs are destroyed.

   The system involves four lenses and two detectors C and D. In the first lense the incoming photon beam splits to reflected and transmitted beams: the path travelled by transmitted beam contains the bomb.

   (a) The bomb absorbs photon with a probability which tells the fraction of photon beam going to the path at which bomb is (is transmitted through the lense). The other possibility is that this measurement process creates a state in which photon travels along the other path (is reflected). This photon goes through a lense and ends up to detector C or D through lense.

   (b) If the bomb is dud, photon travels through both paths and interference at the lense leads the photon to detector D. If C detects photon we know that the bomb was not a dud without exploding it. If D detects the photon, it was either dud or not and we can repeat the experiment as long as bomb explodes, or C detects photon and stop if the detector continues to be D (dud). This arrangement can be refined so that at the ideal limit no explosions take place and all.

2. The measurement of bomb property is interaction free experiment in the sense that state function reduction performed by absorber/bomb can eliminate the interaction in the sense that photon travels along the path not containing the bomb. One might say that state function reduction is an interaction which can eliminates the usual interaction with photon beam. State function reduction performed by bomb can change the history of photon so it travels along the path not containing the bomb.

This picture is only metaphorical representation of something much more general.

1. In TGD framework the photon paths branching at lenses correspond to branching 3-surfaces analogous to branching strings in string model and photon wave splits to sum of waves travelling along the two paths.

2. Bomb could be of course replaced with any two-state system absorbing photons in one state but not in the other state, say atom. Now one would test in which state the atom is gaining one bit of information in the optimal situation. Two-state atom could thus represent bit and one could in principle read the bit sequence formed by atoms (say in row) by this method without any photon absorption so that the row of atoms would remain in the original state.

Memory recall as an interaction free measurement

One can imagine several applications if the information to be read in interaction free manner can be interpreted as bit sequences represented as states of two-state system. Lasers in ground states and its excited state would be analogous many particle quantum system. In TGD framework the analog of laser consisting of two space-time sheets with different sizes and different zero point kinetic energies would be the analogous system.

For instance, a model of memory recall with memories realized as negentropically entangled states such that each state represents a bit can be considered. The model applies also to the reading of future plans (memories on reversed time direction).

1. Reading of a particular bit of memory means sending of negative energy photon signal to the past, which can be absorbed in the reading process. The problem is however that the memory representation is changed in this process since two state system returns to the ground state. This could be seen as analog of no-cloning theorem (the read thoughts define the clone). Interaction free measurement could help to overcome the problem partially. Memory would not be affected at all at the limit so that no-cloning theorem would be circumvented at this limit. Memory bit to be read would be mathematically analogous to bomb in the Elizur-Weizman bomb tester thought experiment in which one tries to determine whether bomb is active (bit 1) and can therefore explode or passive (bit 0) and cannot explode.

2. A possible problem is that the analogs of detectors C and D for a given qubit are in geometric past and one must be able to decide whether it was C or D that absorbed the negative energy photon! Direct conscious experience should tell whether the detector C or D fired: could this experience correspond to visual quale black/white and more generally to a pair of complementary colors?

3. ZEO means that zero energy states appear have both embedding space arrows of time and these arrows appear alternately during periods of repeated state functions having no effect at the other boundary of CD. This dichotomy would correspond to sensory representation-motor action dichotomy and would suggest that there is no fundamental difference between memory recall and future prediction by self model and they different only the direction of the signal.

4. Since photon absorption is the basic process, the conscious experience about the bit pattern could be visual sensation or even some other kind of sensory qualia induced by the absorption of photons. The model for the lipids of cell membrane as pixels of a sensory screen suggests that neuronal/cell membranes could serve defined digital self model at the length scale of neurons.

Some comments are in order.

1. To avoid misunderstandings it should be emphasized that TGD based view about memory is not the same as the standard view. In ZEO brain is four-dimensional and in principle memories can be negentropically entanglement memories in geometric past. It is possible to build copies of memories by memory recall, and learning would correspond to a generation of large enough number of copies of the memory mental image. Memory recall could be seen as a negative energy signal inducing the interaction free measurement of memory qubits. Dark photons with EEG frequencies (say in theta band characterizing hippocompus) but having energies of visible photons could be involved with the memory recall. Correlation between EEG and bio-photons supports this view.

2. If the systems taking the role of the detectors C and D in interaction free measurement are analogous to population reversed lasers, their return to the ground state could automatically generate virtual sensory input propagating to the sensory organs and allowing to check whether it is consistent with the actual sensory input. The generation of the feedback signal takes some time expected however to be much shorter than that for a typical neuronal activity.

   Since the signals would propagate with light velocity, the virtual sensory input could travel practically instantaneously from the brain to sensory organs and possibly also vice versa. Libet's experiments on passive aspects of consciousness [J52] in fact demonstrate a time delay which is fraction of second having interpretation in terms of time to propagate to a layer of magnetic body of size scale of Earth and back: these delays are consistent with the fact that the chronon of sensory experience is about.1 seconds. The propagation of photon signals in both directions would make possible construction of sensory representation in time scale much shorter than that of neural activity. This mechanism could also explain generation of after images.

3. Photons can be replaced with phonons or quanta of any other wave motion with constant propagation velocity (no dispersion of signal) in a given reference frame. This suggests that imagination and internal speech correspond to the two reading mechanisms of memories.

11.4.2   Why Vision And Hearing Are So Fundamental For Cognition?

The interaction free measurement of bits of sensory and memory representations is formulated in terms of photons. It can be however formulated also for sound waves using phonon detectors and acoustic waves traversing through two different paths. Quantum coherence is required but the hierarchy of Planck constants makes sense also for phonons by the basic equation $E = hf$.

In TGD framework there are good reasons to believe that sound waves are not only something emerging at the level of condensed matter but correspond to oscillations of string like objects at 4-D space-time surface. These strings connect the wormhole contacts assignable to the light-like orbits of partonic 2-surfaces. Partonic 2-surfaces can be assigned with elementary particles but also to 2-surfaces with arbitrarily large size scale. The outer boundary of any physical object would correspond to a partonic 2-surface. String world sheets carry fermion fields localized at them (right-handed neutrino is an exception in that it is de-localized at entire space-time surface). The fact that strings always connect two partonic 2-surfaces corresponds to the fundamental two-particle character of sound waves. Sound would be as fundamental phenomenon as photons and other massless bosons.

This encourages to ask whether photon (more generally gauge boson: TGD suggests that scaled up copies of gluons and weak bosons behaving like massless particles even in cell length scale are possible) and photon absorption could define fundamental potentially representations of information in terms of bits realized in terms of interaction free measurements. Negentropic entanglement at the passive boundary of CD would define another representation, which is directly conscious. Negentropic entanglement is possible also at active boundary but is not absolutely stable.

Photons would correspond to "seeing" but at neuronal level rather than at the level of retina - and imagination. Phonons would correspond to hearing at neuronal level and internal speech which is also essential for cognition. Both internal speech and imagination could be understood at fundamental aspects of cognition. Dark photons with energies of visible photons (decaying to

what is interpreted as bio-photons) and dark phonons would be behind imagination and internal speech. I have already earlier proposed that the lipid layers of neuronal membranes (and maybe also ordinary cell membranes) can be regarded as pixels of a sensory map representing neuronal qualia [K50]. These pixels could serve as the counterparts of the detectors C and D appearing in interaction free measurement.

The evidence for the importance of bio-photons (in TGD framework dark photons decay to bio-photons in energy conserving manner) in biology and neuroscience is emerging, see for instance the experiments of Persinger's group [J58, J59, J60]. I have discussed these findings from TGD point of view in [K30]. One can speculate about direct translation between the words of language and visual pre-images. Something like this one might expect.

Biophotons seem to be associated only with the right hemisphere [J58]. This suggests that right hemisphere or some parts of it prefer dark photons being thus specialized to visual imagination in accordance witht the fact that spatial relationships are the speciality of right hemisphere. Could this mean that left hemisphere or some pats of it prefer dark phonons? Left hemisphere indeed is the verbal hemisphere specialized to linear linguistic cognition and produces also internal speech.

11.4.3 Dark Photons, After Images, And Mechanism Of Learning

After images are generated when one stares to bright light source for some time. Anyone can observe how the after images develop. After images drift gradually downwards suggesting that they are indeed generated at the retina and their source drifts downwards in gravitational field. After image also reappears periodically and can change their color in each re-appearance.

It has been suggested that bio-photons could be responsible for the generation of after images. In TGD framework the after images would be generated by dark photons decaying to bio-photons.

1. Delayed luminescence has been proposed as explanation. The light absorbed by retina from intense light-source emitted partially as bio-photons could define the secondary source. This is a possible mechanism since retina is sensitive to even single photon. One can however ask what is the real mechanism behind delayed luminescence.

2. Consciousness theoretic explanation based on the model fo sensory receptor as an analog of capacitor which suffers di-electric breakdown. There is some recovery time. Looking into bright light-source generates visual sensation but requires a long recovery time. The image is regenerated after the recovery. Visual mental images define conscious entities (selves) and just as we do they also would have sleep-awake cycle). Where the sensory input comes or do bio-photons resulting in the decay of dark photon BE condensates generate it. Why the periodic appearance and why the gradual change of color? Could it be that the photons rotate in a large loop identifiable as a closed magnetic flux tube? Does the time constant (length of loop) for a visual receptor depend on the peak frequency for which it is sensitive.

3. Or is a generation of copies of visual memory in question? Magnetic body or brain generates a virtual sensory input as dark photons transforming to bio-photons at retina. Internal speech involves similar echo like effect and also piece of music is recalled repeatedly. Could delayed luminescence provide a mechanism of memory storage: the repetition of the stimulus increases the probability of memory recall in TGD based model of long term memory as a communication with the geometric past?

   As a matter fact, delayed luminescence could be seen to reflect the presence of a deeper level cognitive mechanism rather than vice versa. The periodic appearance of after images could be a process in which retina receives periodically a virtual sensory input - perhaps from magnetic body via brain - and generates as a response nerve pulse pattern, and perhaps also dark photons generating a memory mental image which is negentropically entangled with the earlier memory representation.

   In this process memories representing the after image are read and the interaction free measurement involved with the process excites laser like systems which then generate radiative response defining the virtual sensory input, which then generates genuine sensory input. One

could speak of a repeated echo. Why the color of the after image changes could be understood if the decay of the laser like states generates photons with several energies.

Similar echo generating mechanism for dark phonons instead of photons could explain why during sleep and also during wake-up state some word of internal speech repeats itself.

11.4.4 Realization Of Memory Representations In Terms Of Braided Flux Tubes

The obvious question is how various representations (sensory -, memory -, ...) - "Akashic records" - are realized as negentropically entangled states?

Magnetic body should be the seat of memories in some sense.

1. I have already earlier proposed this kind of realization based on the observation that braiding in time direction generates space-like braiding [K5]. Dancers on the parquette with their feet connected to the wall by threads illustrates the idea. When dancers move at the parquette their world lines define a time-like braiding in 3-dimensional space-time assignable to the floor. Also the threads connecting the dancers to the wall get braided - or entangled - as one might also say. There is clearly a duality between time-like and space-like braidings: the running topological quantum computer program coded by braiding in time direction is stored as space-like braiding defining memory representation of what happened. Note that same mechanism realizes also predictions and future plans as time reversed topological quantum computer programs in ZEO. CDs in various scales contain this kind of programs and their memory representations.

2. I have also proposed that the geometric entanglement - braiding - of flux tubes defines a space-time correlate for quantum entanglement. In the case of topological quantum computation it would be naturally described by probabilities, which are rational numbers (or perhaps even algebraic numbers in some algebraic extension of p-adic numbers characterizing together value of the p-adic prime the evolutionary level of the system). Hence the notion of number theoretic negentropy makes sense and one obtains a connection with topological quantum computation.

3. The representation of memories in terms of space-like braiding of magnetic flux tubes connecting various systems would be universal, and not restricted to DNA-cell membrane system in which the flux tubes would connect DNA nucleotides [K5, K119] or codons (this seems to be the more plausible option [K30]) with the lipids. One could indeed speak about Akashic records (`http://tinyurl.com/5hxjpr`).

4. The time reversals or these representations defined by the zero energy states of opposite arrow of the embedding space time would define a representation for future predictions/ plans in ZEO. For instance, the development of a seed to a full-grown organism could be coded in this manner in time scale where CD has time scale of order of the lifetime of the organism. Already Burr found evidence that the radiation field assignable to the seed has the same shape as the plant [I99, I106] or animal (salamander in his experiments). This energy field would naturally correspond to the magnetic body containing dark photon Bose-Einstein condensates. The Akashic records and their time reversal would naturally correspond to the morphic fields of Sheldrake [L9, I130]: memories and future plans in time scales longer than than duration of life cycle for an individual member of species would be possibles. Every scientist of course agrees that the societies are busily predicting and planning their futures but find very difficult to accept the idea that this could have some concrete quantum physical correlate.

11.4.5 How To Construct And Read Conscious Hologram?

There is also another question to be answered. How the vision about brain as a conscious hologram is realized in the proposed conceptual framework?

The idea about living system as a hologram has strong empirical basis. One of the most dramatic demonstrations of the hologram like character of brain was the discovery of Pietch [J107]

that salamander's brain can be sliced to pieces and shuffled like a deck of cards and put together. When the resulting stuff is returned to the head of the salamander, it recovers! This extreme robustness is very strong support for the non-local hologram like storage of biological information. Ironically, Pietch tried to demonstrate that the theory of Karl Pribram [J96, J97] about brain as a hologram is wrong!

In TGD framework one can go even further and ask whether this robustness actually demonstrates that various representations (sensory - , cognitive -, memory -...) are realized at the long magnetic flux loops and sheets of the magnetic body rather than brain: one of the most disptable ideas of TGDi based quantum biology.

The notion of conscious hologram [K23] is one of the key ideas of TGD inspired theory of consciousness. Hitherto I have not been however able to find a really convincing concrete proposal for how brain could be a hologram in TGD Universe. The reading of memory - and other representations by interaction free measurement however leads to a natural proposal for what the hologram might be.

1. The formation of the hologram must closely relate to the vision about bit representations of memories possibly realized in terms of braided flux tubes and their non-destructive reading by interaction free measurement. Oversimplifying, tor a given bit of the representation the photons scattered without interaction would kick either of the two detectors C and D associated with it to an excited state (see `http://tinyurl.com/y86ysuyd`). This process is very much like absorption of photons by a photosensitive plate defining an ordinary hologram.

2. The lipids of the cell membrane are good candidates as something in 1-1 correspondence with the basic units of this hologram (note the analogy with computer screen - also a liquid crystal!). If one irradiates the laser like system formed by the detectors not only by the radiation scattered from the memory bits sbut by its superposition with the reference wave of same frequency, one obtains a good candidate for a hologram. It would be defined by the excited quantum state consisting of laser systems analogous to the detectors C and D. Any piece of the system should give and approximate representation of the memory and robustness of the representation is achieved.

3. In semiclassical treatment the probability that a given laser like detector is excited must be proportional to the modulus squared of the net field amplitude, which is a superposition of reference wave and scattered wave Also just. as in the case of ordinary holograms, the irradiation of the laser like system by the negative energy counterpart of the reference wave (its phase conjugate emitted in a state resulting in state function reduction to the opposite boundary of CD) effectively generates the conjugate of the scattered wave since only those parts of the system can return to the ground state with considerable probability for which the probability to go to excited state is high enough. Note that this implies that magnetic body contains geometric representations of the perceptive field as indeed assumed [K60, K61]. This is however not quite the classical hologram. Rather, the total number of absorbed negative energy phase conjugate photons for given pixel defines the "real" picture. A given point of the hologram corresponds to an ensemble of laser like detectors so that a statistically deterministic response is obtained as an ensemble average.

How to realize this concretely?

1. The lipids of cell membrane could serve as pixels of sensory representations [K50] defining conscious holograms. Each pixel should contain large number of laser like "detectors" so that statistical determinism would be achieved.

2. The basic structural element would be pair C and D of detectors such that either of them absorbs photon in an interaction free measurement so that a value of bit is defined. Universality serves as a strong constraint as one tries to guess what C and D could be.

   (a) The lipids at the two lipid layers of cell membrane could be in 1-1 correspondence with C and D. This option is not however universal.

(b) It is however quite possible that the magnetic fields involved are what I have called wormhole magnetic fields [K125], which carry monopole fluxandinvolve two space-time sheets carrying opposite net fluxes. As a matter of fact, all elementary particles correspond to flux quanta of wormhole magnetic fields. In this case the two sheets would naturally correspond to detectors C and D and in the simplest situation they would have same Minkowski space projection. Universality of both detectors and holograms is achieved.

3. The cyclotron Bose-Einstein condensates for charged particles at magnetic flux tubes assignable to lipids are good candidates for the laser like systems if they contain cyclotron Bose-Einstein condensates. There are however several options since the magnetic flux tubes are closed and there are several ways to realize this.

(a) DNA as topological quantum computer vision [K5] and the view about cell membrane as a sensory receptor communicating data to the magnetic body in turn sending control signals via DNA suggest the following. Magnetic flux loops have a part connecting DNA with nuclear or cell membrane (this would be the analog for the dipole of the dipole magnetic field) and part which is long - even with size scale of Earth and corresponds to the magnetic field created by the DNA-cell membrane system. This picture applies both to the flux tubes of ordinary magnetic field and to the flux tubes of the wormhole magnetic field.

(b) An assumption in accordance with the general role of magnetic body is that Akashic records reside at the short portions of flux tubes connecting lipids with DNA codons: their braiding would define basic example about universal representations in living matter. The laser like detectors would reside at the long portions of the flux tubes connecting cell membrane and DNA. If wormhole magnetic fields are in question, the detectors C and D could correspond to the two parallel flux tubes carrying opposite monopole fluxes.

(c) Universality suggest that this picture allows many alternative realizations. In principle, the relative motion of any system (partonic 2-surfaces with light-like orbits) connected by flux tubes could give rise to Akashic records. The lipids of axonal membrane are excellent candidates for the pixels and the flux tubes connecting the lipids to microtubuli [J8] would also define Akashic records with long parts of the flux tubes serving as the laser like system. The maximization of the memory capacity would also explain why the neural pathways to brain tend to maximize their lengths by connecting right side of the body to left hemisphere and vice versa.

4. What remains still open is how to integrate the Josephson junctions defined by the lipid layers of the cell membrane to this picture.

11.4.6 Some Critical Questions

There are two basic objections against quantum theories of consciousness. How it is possible to have conscious information about invariant under quantum jumps if only change is experienced continuously? The outcome of state function reduction in standard quantum theory is random: how can one understand freedom of choice and intentional behaviour in terms of state function reduction? NMP and the possibility of negentropic entanglement (see **Fig. http://tgdtheory. fi/appfigures/cat.jpg** or **Fig. ??** in the appendix of this book) imply that TGD based quantum theory is not equivalent with the standard one, and this allows to circumvent the objections.

The experiments carried out to test whether 40 Hz thalamocortical resonance is correlate for conscious experience suggests that the resonance is present only when a new pattern is discovered, not when it has become a memory. The TGD inspired interpretation would be that the resonances accompanies negentropy gain and quantum jump is necessary for a conscious experience. However, the reports about higher states of consciousness suggest that the invariants can be experienced directly when all thoughts (interaction free measurements) are eliminated. This experience cannot

be however communicated: one understands does not know what one understands. Therefore also the original vision that negentropic entanglement corresponds to a conscious experience - experience of pure understanding, which is not communicable - and in apparent contradiction with the basic hypothesis about quantum jump, would be correct after all! Only the identification of the hierarchy of quantum jumps as self hierarchy would be wrong.

11.5   Taos Hum As Evidence For Biophonons?

Taos hum is an experimentally well-established anomalous phenomenon which has escaped rational explanations (in the article [I93] a thorough review about nocturnal taos hum is given and the following representation relies on this article). Very concisely, taos hum seems is apparently a subjective experience without identifiable objective counterpart, and could therefore correspond to dark photons and/or phonons eventually transforming to ordinary sound and generating the experience. In the following basic facts about taos hum are summarized and some alternative TGD inspired explanations of taos hum are considered besides the original explanation as microwave hearing.

11.5.1   Basic Facts

Taos hum is perceived in and around Taos, New Mexico but similar phenomena are experienced also in Northern America and Northern Europe. The hum is mostly heard during night time. Most people experience the hum as irritating and it causes nocturnal disturbances. From the tests based on psychophysical matching the frequency range of the hum has been deduced to be 40-80 Hz and whereas amplitude is around 60 dB. The hum is a regional phenomenon. The hum does not usually appear between sunrise and sunset. The pitch and intensity of the hum varies inside house and finds the largest magnifications on lower floors. Rooms modify the hum by adding distinctive harmonics to it. The pitch of the hum changes when one moves from outer wall to the interior rooms. Hallways and small alcoves raise the pitch considerably. The wavelengths involved vary between 3.9-7.8 meters for 40-80 Hz frequency range which suggests that resonance effects could be involved. It has been however impossible to identify any acoustic origin for the phenomenon. The presence of effectively acoustic effects suggests that a gigantic amplification by the physical (and magnetic!) body of the patient is involved.

Hum can involve also an experience about whirling or roaring wind, kind of vortex although nothing moves around, and coming from all directions. Also a strange amplification of distant sounds can be experienced. White light in the horizon in the direction where hum comes from can be also perceived. Experiences analogous to hum have been reported also in past, even in antique ("Aeolian wind"), but nowadays the number of victims of the hum has increased, which suggests a connection with the emergence of electronics and computers. The direction which hum is experienced to come from seems to be random.

The hum can be accompanied by irritating tactile sensations and neuralgic pain. The unfortunate individual who suffers of extreme HUM disturbances, seems to be controlled by very fundamental and autonomic response-reflexes when in it grips. Such sufferers may behave in semiconscious modes, modelling behavioral patterns seen only in animals. Typically the victim tends to get underground believing that this allows to get him rid of the hum. The victims of hum indeed tend to wake up with the realization that they have very strong and painful muscle tenure.

An important hint as regards to mechanism of hum is the fact that the temporal patterns of the shortwave radio static detectable by shortwave receivers correlate strongly with those associated with the hum. It is also known that the static has a biological origin: the warbling sounds characterizing the static resemble those produced by plants and galvanic skin response sensors. And most importantly, the statics is present during night time.

All attempts to detect the hum instrumentally and to identify its source have failed. This has inspired various kinds of conspiracy theories about the nature of the phenomenon, for instance, the proposal the strong ELF power feed by submarine radars alone could explain the phenomenon.

11.5.2 Phenomena Possibly Related To Taos Hum

It is appropriate to discuss first some phenomena possibly related to the taos hum before considering the model for the phenomenon itself.

Microwave hearing

Microwave hearing [I63] is a phenomenon in which microwaves generate an audible sensation. There is evidence that microwave hearing does not involve ears as receivers of the primary signal [I39] and that the sensation of hearing could result as back-projection from cortex to ears.

This, and the correlation with microwave static suggest that taos hum could be a particular case of microwave hearing. The model of sensory representations implies that brain acts as a sending microwave antenna: a natural implication is that brain can act also as a receiving microwave antenna. The size of the brain hemisphere corresponds to a microwave frequency of order 3 GHz and smaller structures inside brain correspond to higher radio frequencies.

If primary sensory organs are the seats of the sensory qualia and back-projections cannot induce physical pain, the presence of the painful tactile sensations means that microwaves - assuming that they underlie Taos hum - also must interact also with the sensory receptors at the skin.

Why taos hum? Could animals use microwaves for "seeing" in absence of sunlight? But for what purpose plants would use microwaves? Could organisms send negative energy $h_{eff} = n \times h$ [K37, K38, K39, K40] microwaves to environment and suck metabolic energy quanta with energy around .5 eV in this manner? Remote metabolism! Or maybe time reversed photosynthesis in dark! Biophotons indeed have energy spectrum in visible and UV as also sunlight does. This would require non-standard value of Planck constant.

This hypothesis would explain why the microwaves causing taos hum not hum are not observed directly. And if something is sucking metabolic energy from you, it is would be rather natural to experience very unpleasant feelings and try to find a place to hide as many sufferers of taos hum try to do!

Physiophonic effect

Physiophonic effect is a phenomenon accidentally discovered by Antonio Meucci in 1842, in which vocal signals are electrically transmitted directly into the neurology of listeners [I93]. Physiophonic sound can be often amplified to an enormous volume. A possible interpretation is as externally stimulated internal sound but one can of course wonder whether the transduction to sound is necessary.

Since the body (especially collagen network) is liquid crystal allowing piezoelectric effect in which mechanical vibrations are transformed to electric signal, external sounds could be transformed to electric fields. On course, LC property implies that also genuine sound is generated so that both ELF em fields and ELF sounds can act as amplified signals. One can ask whether strong back-projection to the ears is generated so that sound percept results. This would imply oto-acoustic sounds directly detectable by microphones not found in the case of taos hum.

Microwave static and taos hum

It is known that the temporal patterns of the shortwave static detectable by shortwave receivers correlate strongly with those associated with the hum. It is also known that the static has a biological origin: the warbling sounds characterizing the static resemble those produced by plants and galvanic skin response sensors. And most importantly, the fact that the static is present during night time would explain why hum is experienced at night time.

11.5.3 Possible Ingredients For The Model For Taos Hum

The facts about the role of the musculature, shortwave radio noise, and the role of acoustic environment combined with the model of microwave hearing based on the notion of dark photons [K57] pose strong constraints on the model of taos hum.

Taos hum as sensitivity to external biological control signals

Magnetic bodies control biological body by sending control commands to brain and body where they are transformed to nerve pulse patterns and various physiological waves. Also the lower levels of self hierarchy should control the respective levels of the hierarchy, in particular muscle cells, in a similar manner. In the case of hum patient the normal control signal could be replaced by a control signal from some external biological source, say plants, and would be responsible for the muscular vibrations amplified to the hum. In the worst situation the behavior of hum patients reduces to simple reflex actions: these reflex actions would be initiated by fake control signals.

The fact that the taos hum begins after the sunset would conform with the interpretation as sucking of metabolic energy with energy quanta in visible and UV range. The loss of metabolic energy could explain why the experiences of patients are so unpleasant. Since motor action is based on negative energy signals affecting directly neuronal membranes by the same mechanisms as ordinary motor actions the signals would also induce reflex actions.

The situation could be due to the failure of the em (or rather, electro-weak) immune system of the patient. In order to understand what is involved a brief discussion of model of motor control based on charge entanglement induced by W MEs is necessary: a detailed model is discussed in [K53, K57].

1. The exotic ionization of dark matter induced by W MEs generates dark plasma oscillations inducing electric fields which by many-sheeted variant of the Faraday law induce electric fields also at the space-time sheets where ordinary matter resides. Various ionic waves, in particular Ca^{2+} waves and nerve pulse are examples of the physiological responses resulting in this manner.

2. Dark plasma frequency corresponds to a microwave photon with energy above the thermal threshold and the system must be able to provide dark photons with this energy to generate plasma oscillation patterns serving as control commands.

   The electro-weak immune system could fail in the following manner.

1. In the healthy situation em immune system takes care that the body is tuned to the personal dark plasma frequencies and does not respond to control commands from alien magnetic bodies associated with, say, plants.

2. In an un-healthy situation persons plasma oscillation frequencies are tuned to some frequencies in the microwave static and microwave static provides the energy needed to generate plasma wave patterns and thus to realize control commands from the alien magnetic bodies. The plasmoids would induce microwave hearing and generalized motor actions at cellular level exhausting the personal metabolic sources and leading to the painful experiences and fatigue.

Taos hum and microwave hearing

The identification of the audible sensation associated with taos hum in terms of microwave hearing could explain the failure of the attempts to identify the source for taos hum. Amplitude modulation by ELF frequencies naturally associated with motor control would give rise to sensation of sound.

Concerning the model for microwave hearing, a good guideline is that the effect is expected to be possible as quantum effect only if the energies of the microwave photons are above the thermal threshold. This would require dark microwave photons for which 5 GHz photons have energy above thermal threshold (6 cm wavelength). Same applies to other effects caused by dark microwave photons.

Microwave hearing itself would rely on hearing of dark microwave photons at visible and UV frequencies. These dark microwave photons could accompany the microwave signal automatically or could be generated by cells via a phase transition increasing the value of Planck constant.

Taos hum and microwave seeing

The de-coherence of microwave photons to ordinary photons would produce the biological effects. This could explain also the reported perception of white light as resulting from the de-coherence of the microwave photons at the upper end of the spectrum: 1 mm microwave wavelength would correspond to 2.5 eV photon energy.

The de-coherence of dark microwave static to ordinary visible photons could make possible microwave vision during night time. This could explain why the static emerges after the sunset. Plants could also generate negative energy dark microwave photons with energies in the frequency bands of visible photons involved with photosynthesis to satisfy their metabolic needs when they do not receive sunlight. One can of course wonder whether the quartz in the rock heated during day-time could generate dark microwave photons during night-time serving as a metabolic source.

Taos hum as a failure of the electromagnetic immune system

Taos hum starts immediately after the sunrise and stops after the sunset and seems to have a biological origin. The magnetic bodies of (say) plant cells could send dark energy photons at microwave frequencies above 5 GHz: one reason is that they become visible in this manner.

Negative energy W MEs in the same frequency range and responsible for quantum bio-control in the time scale of microwaves could be involved. Due to the failure of the electro-weak immune system the surrounding biosphere could induce generalized motor actions and these would exhaust the metabolic energy resources of the victim. This would explain why the hum is intolerable and the extreme fatigue caused by it.

The radio noise generated by computers and other sources of radio waves should not cause troubles if these radio waves correspond to ordinary photons. If not, then the microwaves in question could provide the energy needed to realize alien control commands based on ELF modulation.

An explanation for 40-80 Hz modulation

The model of biological evolution and evolution of nervous system based on dark matter hierarchy [K44] leads to sa detailed identification of the values of Planck constant associated with EEG identified as of dark Josephson radiation with energies in visible and UV range and EEG frequencies. This level is involved with all life forms capable of genetic expression, in particular plants. Therefore the ELF modulation of microwave frequencies could be due to the control commands from the levels of the magnetic body normally meant to control the genetic expression of say plants. The modulation of the microwaves with EEG frequencies, in particular with the frequencies in the $37 - 44$ Hz thalamo-cortical resonance band, could force the patient to stay awake by not allowing the dominant EEG frequencies to drop down to theta and delta region of EEG as occurs during sleep.

Is stochastic resonance involved?

One could also ask whether the microwave static of victims of taos hum is anomalously amplified by some mechanism so that control commands from alien magnetic bodies can be realized. The transduction of weak microwave signals to mechanical oscillations by piezo-electric body liquid crystals, and the amplification of this signal in the presence of a metabolic energy feed to the musculature, could lead to this kind of situation.

Stochastic resonance with white noise generated by body provides one possible amplification mechanism. Micro-wave frequency would correspond to the amplified frequency. If so, one could perhaps understand why only some persons experience the hum and why the effect is strong at night time. White noise would be generated by body. White noise induces jumps between the states of the 2-state system with an average frequency f_K (Kramers frequency) which depends on the autocorrelation function of the white noise and the properties of the 2-state system [K95]. If the Kramers frequency satisfies $f_R = 2f$, where f is the frequency of the signal, a resonant amplification occurs. The dependence $f_K \propto exp(-\Delta V/D)$, where $\Delta V > 0$ is the height of the potential barrier separating the states of the 2-state system, implies and exponential sensitivity of f_K on $1/D$, where D is the intensity of the white noise. Hence the failure of the em immune

system could be due to the too intense white noise produced by the body of the victim or due a too low height of the potential barrier.

Are electronic systems involved with the hum?

The fact that the number of victims of hum has rapidly increased during the era of radio communications and computers and suggests that both radio noise and computers might be actively involved with the hum. Also ELF noise from electronic systems might be important if these systems generate dark ELF photons.

Electronic instruments generate also frequencies in the range $40 - 80$ Hz, in particular the 50 Hz frequency associated with the household electricity. Also submarine radars generate very strong ELF signals. The liquid crystal character of human body implies that besides weak sound signals also these ELF signals can contribute to the signal amplified by musculature. If these signals correspond to the lowest level of dark matter hierarchy, they should not have biological effects but whether this is the case is not all clear.

The strong coupling between magnetic flux tube structures associated the with computer networks and sensory canvases might be created by the magnetic reconnection process during night time when the shape of the flux tube structures changes. Also whole-daily use of a computer could generate magnetic mirror bridges between the computer and user's musculature and allow computer to feed fake control signals to muscles.

11.5.4 How TGD Approach Could Explain Taos Hum?

The original explanation for taos hum was as analog of microwave hearing.

1. According to the original explanation, taos hum could be understood in terms of this kind of Josephson radiation or more general radiation at microwave and also higher frequencies generated by living matter during night-time and possibly providing some organisms with an active "vision". The emission of negative energy dark photons could also make it possible for plants to suck metabolic energy from environment in the absence of solar radiation. This radiation would propagate along magnetic flux tube - ME pairs. Microwave hearing or its analog at higher frequencies would generate the experience of hearing. The question is what exactly happens in in microwave hearing or its analog.

2. The estimated wave length λ for sounds assignable to taos hum are in the range 4-8 meters: this estimate might comes from the correlation with the acoustic environment. Probably it comes simply from the formula $\lambda = c_s/f$, where $c_s = 3 \times 10^3$ m/s denotes sound velocity in air and f is the frequency 40-80 Hz assignable to the auditory experience on basis of neurophysiological correlates. This estimate must be taken with a big grain of salt.

   If the primary signal is dark photon signal $f_l = 40 - 80$ Hz and if one takes the wavelength estimate seriously, one obtains the estimate $f_h = c/\lambda \simeq .05 - .1$ GHz. Unfortunately this frequency range is below the microwave frequencies varying in the range.3-300 GHz but scaling down of wavelength estimate by less than an order of magnitude would improve the situation. Thermal energy at room temperature corresponds roughly to 2.5×10^3 GHz so that the energies would be below the thermal energy at physiological temperatures. This cannot be however used as a serious objection against interpretation as microwave hearing since the wavelength estimate is based on the effective assumption that signal corresponds to 40-80 Hz ordinary sound wave.

The TGD based model for EEG [K44] is based on dark Josephson radiation generated by cell membrane Josephson junctions in the energy range of visible and UV light and covering a wide frequency range. The model explains bio-photons and EEG as manifestations of one and same basic phenomenon: dark photons and the recent observations support this identification [J58]. This motivates a more radical explanation of taos hum.

1. The auditory information is presumably coded to modulations of carrier wave with frequency f_h by frequency $f_l = 40 - 80$ Hz, which is in EEG range and could be assigned with the

magnetic interaction energy of dark protons assignable to the opposite sides the cell membrane [J85] [K30]. Dark photon wave length would be of the order of the radius of Earth and the only reasonable explanation for the claimed correlation with the acoustics of the environment is that magnetic body provides a representation of biological body and environment as indeed proposed (magnetic sensory canvas hypothesis [K60]).

2. Since Josephson frequency characterizes the cell membrane frequency scale, one might expect that the dark photons signal has the same frequency. In this case the wave length would be of the order $\lambda = c/f \sim .1$ mm, size scale of large neuron rather than the naïve estimate $\lambda = 4 - 8$ meters.

3. The dark photon signal would be generated by an amplitude modulation of a carrier wave at Josephson frequency $f_h = 2eV \sim 5 \times 10^{12}$ Hz (for electronic Cooper pairs) by frequency $f_l = 40 - 80$ Hz. According to the conjecture proposed earlier [K30], this would generate dark photons with $\hbar_{eff} = f_h/f_l \sim 1.2 \times 10^{11}$ near the thermal threshold. It is highly interesting, Cyril Smith reports that the frequency ratio $f_h/f_l = 2 \times 10^{11}$ is involved with the transformation of high frequency signal to low frequency signal [J27].

4. This picture would conform with the original idea that left brain utilizes frequencies not smaller than Josephson frequency assignable to cell membrane and right brain hemisphere visible and UV frequencies. In TGD framework this difference would be due the fact that cell membrane can appear in two ground states [K50]. The state realized in right hemisphere near to the vacuum extremal with Josephson frequencies in visible and UV range and the state realized in left hemisphere far from vacuum extremals and Josephson frequencies derivable from membrane potential.

One should also understand how dark photon signal transforms to dark phonon signals and how this signal transforms to ordinary sound generating the taos hum experience. Two options can be considered: for the first option only dark photons are involved, for the second option both dark photons and phonons are involved.

1. Living body - cell membrane is an electret - and thus transforms electric signals to sound waves and vice versa. The minimum option is that signal propagates as dark photons and transforms to dark phonons of same energy at cell membrane level. One can consider also second possibility: dark photons continue to propagate along ME-flux tube pair parallel to the axonal membrane.

2. Dark phonons in the high frequency optical branch of the spectrum (/photons) would propagate as oscillations assignable to axonal membrane (/ME - flux tube pair parallel to it) to ear. Dark phonons/photons would generate virtual auditory percept by transforming to ordinary phonons at ear.

3. Both the variants of the model could explain the basic findings about taos hum, in particular the fact that it creates a subjective experience without any objective counterpart.

One can ask why taos hum is not accompanied by its visual counterpart involving dark photons with visible photon energies. In fact, the persons suffering from taos hum occasionally report experiences of white light in the direction of sound. The mechanism could be essentially the same as for taos hum except that the right brain hemisphere is a better candidate for the receiver now if one takes TGD inspired view about cell membrane seriously.

11.6   Dark Photons In Biology And Neuroscience

In this section I want to add some details to the general vision about dark photons as deeper level behind bio-photons. What is certainly unusual that I will barely mention biochemistry. My knowledge about the complexities of biochemistry is not the reason for the neglect. The reason is that if hardware-software dichotomy in biology corresponds to the matter-dark matter dichotomy, the biochemistry separates neatly from the physics of dark matter for the software. It is a physical fact that dark matter dominates over ordinary matter in cosmic scales and is present everywhere

so that it is not so surprising if dark matter would play a key role in biology. Recently the futile searches for WIMP (weakly interacting massive particle) with expected properties have forced particle physicists to ask whether dark matter could be much more than single WIMP, maybe a new phase of matter or even hierarchy phases as TGD suggests.

My basic defense for the notions of magnetic body and dark photons (also other dark particles) is that they follow from the basic TGD and allow to explain phenomena very difficult to understand in the standard biochemistry framework - consider only the correlation between EEG and bio-photons, coherence of bio-photons, and delayed luminescence.

11.6.1 General Vision

I have already explained the basic ideas about bio-photons as decay products of dark photons. In the following I try to develop a general vision about the role of dark photons in living matter.

1. Pulse patterns or temporal polarization patterns travelling along MEs are ideal for communications and control because of precise targeting, absence of dispersion and maximal possible signal velocity.

2. Resonance frequencies for dark photons could be an essential element in their interactions with biomatter. The most important of these interactions would be the generation of negentropic entanglement between new representations of mental images and already existing corresponding representations. For instance, for cyclotron Bose-Einstein condensates the magnetic fields at the ends of the sender and receiver must be equal in good accuracy. Password mechanism is suggestive: several resonance frequencies would define the letters of the password. Among other things this could lead to a selective remote activation of gene expression if dark photons represent codons of the genetic code [K127].

The vision of Hawkins about fundamental algorithm [L13] might find realization in TGD framework in terms of the basic anatomy of quantum jump in zero energy ontology (ZEO) [L15]. The basic idea is that conscious information processing consists of pairs formed by sensory perceptions (involving the recognition of the objects of the perceptive field) and by motor action. Sensory perception and motor action are related by time reversal and correspond to state function reductions at opposite boundaries of CD. These processes can combine to complex program like structures via generalization of lock and key mechanism in which fitting of the key to lock corresponds to recognition.

Lock and key mechanism is a well-known mechanism of bio-catalysis, and allows a far reaching generalization. Dark photons could provide a very general non-local realization of this mechanism.

1. Lock and key mechanism allows to imagine biochemical programs consisting from reactions proceeding in fixed order. The idea is same as in a familiar game of children. At each step player gets a key of a room containing a new key and the task is to find the room. After visiting many rooms the successful player eventually has the key to the room containing the treasure. In computer languages like LISP the same idea is realized: program is represented as a collection memory location containing two addresses: the address of memory location and the address of the next memory location. Associative memory recall could rely on the same mechanism.

2. Lock and key mechanism can be realized in several ways. The most concrete manner is as a chemical reaction in which reactants have complementary surface geometries fitting like lock and key. Keys could be replaced with passwords. The password could be represented as a collection of resonance frequencies. Also a pulse sequence or a more general temporal field pattern such as a sequence of magnetic fields with discrete valued strength and duration (Persinger has found that this kind of sequences are "physiologically effective" [J58, J60]. Temporal polarization patterns are also possible and are suggested by Gariaev's group [I55].

   For frequency coding, a given step in the process would activate a collection of frequencies activating the next step of the program and magnetic flux tube connections along which signals propagate would allow to achieve highly selective activation.

3. The decomposition of quantum jump to state function reductions at opposite boundaries of CD explaining the sensory-motor dichotomy at the level of brain could be realized also at molecular level and define basically a pair of addresses/passwords. Sensory perception with recognition of the objects of the perceptive field would correspond to the fitting of the key to lock. The frequencies of future directed positive energy signals would serve as a password inducing a motor action generating a collection of frequencies of past directed negative energy signals serving as a password for the next step of reaction.

11.6.2 Dark Photons And Biology

A lot of experimental data about the role of bio-photons in biology exist [I72, I83, I118]. Coherence [I70] and closely related delayed luminescence [I37] are the basic poorly understood aspects of bio-photons. Already Gurwitsch demonstrated that mitogenetic radiation makes possible communication between cell cultures.

1. Passwords realized as frequency patterns could be at work also at the level of genome and rely on use of portions of DNA sequences as pairs of addresses. One could imagine a representation of DNA sequences in terms of frequency patterns of em fields.

2. Password mechanism realized in terms of frequencies for dark photons could allow interaction between remote genomes. One can imagine remote DNA replication, remote transcription and translation [K53]. If one accepts dark DNA [L3, K53] similar processes involving dark DNA and ordinary DNA can be imagined. I have discussed the role of dark DNA in making possible kind of R&D department allowing to test new variants of genes in the virtual world of dark DNA, RNA, tRNA and dark amino-acids. Peter Gariaev's findings suggest the possibility of remote DNA replication and remote activation of gene expression [K127].

3. The mechanism for the generation of sensory -, memory -, and cognitive representations as negentropically entangled zero energy states getting new tensor factors during quantum jump sequence is extremely general. Same can be said about the interaction free measurement as a mechanism for nondestructive reading of these representations. This suggests that they are realized already at the biomolecular level so that also conscious intelligence is present already at nanolevel. What we call molecular machines would be conscious entities and swarm intelligence as a mechanistic algorithm would be replaced by self-organization of conscious entities able to co-operate thanks to the presence of collective levels of consciousness made possible by the magnetic bodies and flux tube reconnections generating larger quantum coherent structures.

4. One can imagine new mechanisms of metabolism based on dark photons. Dark photons could take the role of sunlight and provide energy for electrons in electron transport cycle appearing in both cell respiration and photosynthesis. The effect of visible laser light on skin might involve this kind of mechanism. Negative energy dark photons emitted by electrons would make possible remote metabolism (quantum credit card mechanism).

5. The possibility to transform ordinary photons to dark photons is what one should understand. The findings of Peter Gariaev [I55] can be explained in TGD framework if DNA transforms laser photons to dark photons with frequencies of radio waves extending at least to kHz. Somehow DNA is able to induce the phase transition changing the value of $\hbar_{eff}$: amplitude modulation by radiofrequencies is a good candidate for mechanism in the case that the frequency ratio equals to integer valued ratio $\hbar_{eff}/\hbar$.

11.6.3 Dark Photons And Brain

The role of dark photons in imagination and for memories has been already discussed. Dark photons could also have a role in vision.

1. In TGD inspired theory of consciousness sensory qualia are assigned with sensory receptor. These primary sensory mental images are negentropically entangled with the mental images at brain and magnetic body (decomposition of perceptive field to objects). Qualia would

represent the colors of perceptive map. This assumption can be justified by very general arguments such as general coordinate invariance implying holography but is not absolutely necessary. Mental images at the magnetic body could be also involved with the entanglement sequence giving higher abstractions about the sensory input.

The basic objection (phantom leg) can be circumvented if one accepts the vision about 4-D brain and TGD view about memory. Pain in phantom leg would be sensory memory of pain in the leg, which still existed. The memory feats of idiot savants and people with left brain damage would be most naturally also due to sensory (visual or auditory) memories. Also ordinary people can have sensory memories when neurons in temporal lobes are stimulated electrically. The pain could be also real but erroneously assigned with the non-existing leg.

2. The notion of sensory window is almost two decades old notion [K79]. In its recent version dark photons propagate along MEs associated with magnetic flux tubes parallel to neural pathways, perhaps both from and to sensory organs. Experimental evidence for the propagation of bio-photons signal between nerve ends [J118] provide support for this idea. Stimulation of other end by light induces bio-photon emission at the other end. What would happen that dark photons are generated a the first end and propagate to other end along MEs and decay to ordinary photons.

3. Seeing without the brain - or more precisely without neuronal connections to brain - is now known to be possible. Does this mean that dark photons mediate information to brain or that retina plus spine "see" and that the geometric aspects of vision are realized also at the level of retina?

4. Dark photons from magnetic body or brain or both to retina transforming there to ordinary photons could provide feedback allowing to transform visual input to stardardized visual mental images. The proposed mechanism would require that retina produces seeds for induced transformation to ordinary photons. This is a testable prediction: does retina generate light? Same mechanism could of course generate photons at the visual cortex so that visual mental images could be generated also there. Dissipation would be also now unvoidable aspect of process and one of the basic functions of metabolism would be regeneration of dark photons.

There is a phenomenon called visual prosthesis referred also to as bionic eye (`http://tinyurl.com/9kasp3q`) providing support for the idea that also neurons can see. Bionic eye can provide the effect sense of vision in a situation when there is degenerative disease of photoreceptors and even for people born blind. Of course, the visual experience need not be same as for ordinary vision: it is possible to "see" geometric information about environment using only tactile sense. In any case, the sensation of vision is at neuronal level unless some functions of retina are still active: I do not know whether this must be the case or not.

The basic visual sensation is phosphene (`http://tinyurl.com/l8vpbu`), kind of diffuse light spot. If phosphenes are basic building bricks of also ordinary vision, the hypothesis that primary sensory organs are carriers of qualia can make sense only if prosthete vision is fundamentally different from ordinary vision. This is possible. Neurons can "see" in TGD framework (I have talked about neuronal windows): at this level vision relies on the reception biophotons travelling along magnetic flux tubes assignable to neuronal pathways. Retinal receptors would be specialised on vision and much more effective than neurons, which would detect just the presence of light.

5. This picture would make possible similar representations also for the other sensory modalities. For instance, people learn to "see" via tactile sensation and also by hearing.

Correlations between bio-photons, EEG, and neural activity

The recent experimental understanding about correlations between emission of bio-photons and neural activity of the brain is thoroughly discussed in [J61].

1. *In vivo* experiments of Kobayashi *et al* [J51] demonstrate that the spontaneous ultraweak photon emission from a rat brain correlates with cerebral energy metabolism, EEG activity,

cerebral blood flow and oxidative stress. Van Wijk *et al* [J72] have demostrated significant correlations between fluctuations of alpha wave portion of EEG and bio-photon emission. It has been also demonstrated that neuronal axons can conduct photon signals [J118]. Thus there is a lot of evidence that bio-photons or something behind them are real and could serve communication purposes. Bischof has proposed that visual consciousness is a property of bio-photon field itself [J101]: this kind of conjecture is problematic philosophically and a weaker hypothesis about the correlation with visual consciousness and/or visual imagination looks more natural.

2. The article takes as granted that bio-photons are produced by biochemical processes related to reactive oxygen and nitrogen species (ROS and RNS). There is a strong correlation with oxidative metabolism of mitochondria. If f bio-photons are not fundamental entities, this correlation does not mean that these processes would directly produce bio-photons.

   One can however invent several objections against this mechanism.

   (a) Too short de-coherence time is the basic objection - Tegmark's estimate for the de-coherence time of bio-photons is $\tau \sim 10^{-13}$ seconds. The estimate is rough and gives coherence time increasing with temperature but certainly the lacking 10 orders of magnitude are a real problem and would require that generation of ROSs and RNSs is a highly coordinated mechanism. There are indeed indications that free radicals and their derivatives are necessary for synaptic processes and ordinary brain functions. If magnetic body controls metabolism the underlying quantum coherence could imply the required high spatial and temporal coordination.

   (b) Delayed luminescence is difficult to understand if only biochemistry is behind bio-photons.

   (c) A further problem is the extreme weakness of bio-photon flux - at least in the vicinity of organism where the measurements are made. The argument of authors is that the strong absorption of bio-photons in living matter is the reason for this.

   Despite these difficulties the authors suggest that bio-photons define a new kind of fast signalling accompanying electric signalling (nerve pulses and waves propagating along axonal membranes) and consider a quantum model for the interaction of bio-photons with micro-tubules. As a matter of fact, the idea about microtubules as quantum antennae represents one of the first applications of the notion of "massless extremal" (ME) to biology in [K79].

   I have already described the basic deviations of TGD based model from this picture. Dark photons relevant to biology make themselves visible by transforming to bio-photons by energy conserving manner: this gives rise to frequency pairs (f_h, f_l) with $f_h/f_l = \hbar_{eff}/\hbar = n$. The other member of the pair would reveal itself classically as low frequency classical radiation and second pair as higher frequency photon. The pairing of EEG with bio-photons could be understood in terms of this pairing. The findings of Cyril Smith [J27] would have interpretation of this pairing allowing also other than EEG frequencies as dark photon frequencies. Also the findings of Peter Gariaev [I55] suggest that also radio wave frequencies can appear as dark photon frequencies.

   According to [J61] the evidence for the correlation between neural electrical activity of neurons and bio-photon emissions is however poor. Situation might improve in future but one can ask whether it could be possible to understand the poor correlation.

1. If the transformation of dark photons at EEG frequencies to ordinary photons gives rise to bio-photons, it might be possible to understand the poor correlation. Neuronal activity would modulate membrane potential and the therefore the frequency $f_J = eV/h_{eff}$ of Josephson radiation but not Josephson current determining its magnitude. Note that f_J can be also outside the EEG range and TGD suggests a hierarchy of scaled up variants of EEG.

2. Neural events would have time scale of order milliseconds much shorter than the time scale of EEG so that the frequency modulation caused by them would not be visible in the time scale T_{EEG} of EEG frequencies considered. Only the slow modulations of membrane potential

in time scales longer than T_{EEG} would be visible as a slow variation of corresponding bio-photon energy. The testable prediction is that the time variation of the frequency spectrum of bio-photons directly reflects that of EEG spectrum.

Biophotons and vision

Bischof [J101] was probably the first one to propose that bio-photons might relate directly to vision. The following list of articles by Bokkon *et al* illustrates the development of ideas about the connection between bio-photons and vision. I have included a comparison with TGD based views, which have developed during last two decades and are discussed in chapters of various online books [K79, K60, K86].

- *Phosphene phenomenon: a new concept* [J86].

  It is proposed that the visual sensation of phosphenes (induced by mechanical, electrical, magnetic situli, ionizing radiation, etc..) is due to bio-photon emission inside neurons. Also an interference model concerning the mechanism of interaction between living organisms and electromagnetic fields is proposed. Authors suggests that the biological nonlinearly polarizable double layer allows destructive interference of incoming and reflected waves outside the double layer. As a consequence, in the inside constructive interference would take place at the same time. The proposal is that the interference patterns may play an important role in biological self organization and in biological functions.

  The authors investigate the boundary conditions necessary for explaining these non-linear optical effects in terms of the phase conjugation, and claim that there are solutions of the Maxwell equations which satisfy destructive interference of bio-photons. Necessary provisions are nonlinearly polarizable optically active double layers of distances which are small compared to the wavelength of light. In addition, they have to be able to move into the nodal planes of the impinging waves within a small time interval compared to the coherence time. The claim is that the conditions are likely fulfilled in the optically dense, but ordered and optically excited, highly polarizable living matter.

  In TGD framework phosphenes could result via a transformation of dark photons to bio-photons. The propose interference model is needed to channel the electromagnetic fields inside cells and axons. In TGD framework the nonlinear modification of Maxwell's equations resulting from the fact that gauge potentials as primary dynamical variables are replaced with embedding space coordinates, implies topological field quantization manifesting structures like massless extremals (MEs), magnetic flux quanta (sheets and tubes) and electric flux quanta realized as space-time quanta. Hence precisely targeted beams of dark photons become possible.

- *Picture representation during REM dreams: a redox molecular hypothesis* [J25].

  The proposal is that the visible photons in retina are converted to neural signals, which in V1 are are converted into synchronized bio-photon signals inside the neutrons by neurocellular radical reactions in retinotopically organized V1 mitochondrial CCO-rich (CCO is a shorthand for cytochrome oxidase) visual areas.

  The TGD counterpart for this would be the conversion of the neural signals to dark photon signals to the magnetic body with ROS and RNS reactions inducing a small leakage to bio-photons. One can also imagine that dark photons are generated at regina and travel along visual pathway so that the communications to magnetic body would be much faster. The feedback as dark photons from magnetic body to brain to retina would generate virtual visual input which in wake-up state would be compared with the actual input. During REM dreams only the virtual sensory input would be present. In retina dark photon input would generate bio-photon emission and this kind of emission is observed [J71]. One can wonder whether the dark photon emission from retina reflected from target could give rise to a "lamp" making possible "active" seeing under some circumstances.

  Cytochrome oxidase (CCO) enzyme (see `http://tinyurl.com/6ep3ob`) is integral membrane protein permanently associated with the cell membrane and coded by mitochondrial DNA, and thus directly related to energy metabolism catalysing the reduction of oxygen to

water in respiration and therefore something very primordial biologically. In TGD inspired model CCO would be needed for generating metabolic energy needed to generate dark photons. This would suggest that CCO rich regions are present also in other sensory areas. An interesting question is whether CCO rich regions are present both in left and right hemisphere. There is evidence that bio-photons are emitted considerably only in right hemisphere [J58]. Could this mean that the energy range for dark photons from left hemisphere is different or that dark phonons/biophonons effectively replace dark photons/bio-photons?

- *Visual perception and imagery: a new molecular hypothesis* [J37].

  The authors describe the basic hypothesis that neural signals from retina generate synchronized bio-photon signals by radical and non-radical processes in retinotopically organized visual areas and that these bio-photon signals provide intrinsic pictures in retinotopically organized mitochondria-rich visual areas.

  It is also proposed that long term visual memory corresponds to epigenetic information regulated by free radicals and redox processes. There is indeed evidence that reactive oxygen species and related haem pathway components as possible epigenetic modifiers in neurobehavioural pathology [J78].

  The TGD counterpart of this hypothesis is that dark photons generate representations of visual field at brain and possibly also at various layers of magnetic body with different degrees of abstraction. For dark EEG photons the layers would have size of order Earth radius suggesting a connection with Schumann resonance and magnetosphere as a higher level in the predicted self hierarchy.

  Epigenetic modifications and changes of synaptic connections would correspond in TGD framework to behavioral changes, not genuine conscious memories. The idea that ROS and RNS could perform this "carving" process analogous to the modification of computer hardware (now represented by biochemistry), is attractive. In TGD Universe genuine declarative memories would be however realized in terms of representations based on bit representations (see **Fig. `http://tgdtheory.fi/appfigures/cat.jpg`** or **Fig. ??** in the appendix of this book).

- *Estimation of the number of bio-photons involved in the visual perception of a single-object image: bio-photon intensity can be considerably higher inside cells than outside* [J37].

  Authors consider two objections against biological role of bio-photons. First, bio-photons are a mere byproduct of cellular metabolism. Secondly, the extreme weakness of bio-photon flux does not support the idea that they might have biological significance. Authors however argue that bio-photon production is a controlled process and among other things gives rise to the above mentioned synaptic and epigenetic modifications. Authors also argue that the density of bio-photons inside cells is considerably higher than outside and consider a mechanism in which em fields are confined inside bilayered structures.

  In TGD framework bio-photons are replaced by dark photons propagating along MEs. Their intensity can be much higher and bio-photons would represent a small leakage resulting from the transformation of dark photons to bio-photons. Unfortunately one cannot say much about the rate of this process: p-adic length scale hypothesis however probably fixes it to be inversely proportional to the secondary p-adic time scale (.1 seconds for M_{127} characterising electron) and hierarchy of Planck constants suggests that the rate behaves like $\hbar/\hbar_{eff}$. The strong correlation with metabolism can be understood since the generation of dark photons requires metabolic energy. An interesting question is what happens at other sensory areas: are CCO rich regions present also there?

- *Visible light induced ocular delayed bioluminescence as a possible origin of negative after image* [J38].

  The motivation of the article is the experimental proof of the existence of spontaneous ultra-weak photon emission and visible light induced delayed ultraweak photon emission from in vitro freshly isolated rat's whole eye, lens, vitreous humor and retina [J71]. Authors propose that the photobiophysical source of negative afterimage can also occur within the eye by delayed bioluminescent photons. When one stares at a colored (or white) image for few seconds,

external photons can induce excited electronic states within different parts of the eye that is followed by a delayed re-emission of absorbed photons for several seconds. Finally, these reemitted photons can be absorbed by non-bleached photoreceptors that produce a negative after image.

In TGD framework one could understand the emission of bio-photons from retina as a leakage phenomenon. After images and delayed luminescence in general could be seen as a kind of echo resulting when dark photons travel to brain, maybe also magnetic body and return back after exciting laser like system which returns to it ground state by secondary emission. After images perhaps assignable to dark photons could give build up copies of memory representations. This could also apply to dark phonons: examples about this would be a repetition of single world or simple piece of music occurring during wake-up state and in sleep mentation.

A virtual sensory input propagating to the sensory organs would allow to check whether it is consistent with the actual sensory input. The generation of the feedback signal takes some time expected to be much shorter than that for a typical neuronal activity.

Since the signals would propagate with light velocity, the virtual sensory input could travel practically instantaneously from the brain to sensory organs and possibly also vice versa. Libet's experiments on passive aspects of consciousness [J52] in fact demonstrate a time delay which is fraction of second having interpretation in terms of time to propagate to a layer of magnetic body of size scale of Earth and back: these delays are consistent with the fact that the chronon of sensory experience is about .1 seconds. The propagation of photon signals in both directions would make possible construction of sensory representation in time scale much shorter than that of neural activity.

As special case this mechanism would explain after images. After images would be sensory echoes resulting when the sensory signal travels to magnetic body and back to sensory organs, maybe several times. The time scale for negative after images is seconds and in principle this allows to get some idea about the slow time scales involved with the process and maybe also about the size scales of largest layers of the magnetic body involved.

Biophotons and intelligence

It is gradually becoming clear that bio-photons have a role in brain function. An interesting claim is that the biophoton spectrum is shifted towards infrared as the intelligence of the species develops [I79](see `http://tinyurl.com/ycor8hs3`). The idea is that biophotons are involved with the communications between parts of brain and biophotons with lower frequencies are favored: one reason could be metabolic economy since biophotons have energies in visible and UV range mostly and in humans the extends to near infrared. The observation is that glutamate-induced biophotonic activities and transmission in brain slices represent a spectral redshift feature from animals to humans.

Could TGD based model for biophotons as decay products of dark cyclotron photons help to understand this? In TGD framework dark photons would be involved with communications of biological body with personal magnetic body (MB) [K30, K20]. Bio-photons would result from dark cyclotron photons in energy conserving transformation to ordinary photons reducing the value of Planck constant $h_{eff} = n \times h$ to its ordinary value h. Dark matter as phase of ordinary matter with non-standard value of Planck constant

$$h_{eff} = n \times h = h_{gr} = \frac{GMm}{2\pi v_0}$$

proposed to be generated at quantum criticality [K37, K38, K39, K40]. Gravitational Planck constant h_{gr} was originally introduced by Nottale [E2]. In this formula M is some mass, say that of black hole or astrophysical object, m is much smaller mass, say that of elementary particle, and v_0 is velocity parameter, which is assumed to be in constant ratio to the spinning velocity of M in the model for quantum biology explaining biophotons as decay products of dark cyclotron photons.

Both dark cyclotron photons from MB to brain and analogs of Josephson photons from cell membranes to MB would be involved in biology. When dark photons transform to ordinary photons they can induce molecular transitions. MB would control biomatter by inducing these

molecular transitions. This explains the range of biophoton energies. Also EEG would consist of dark photons in this energy range but frequencies in EEG range and wavelengths of astrophysical size (7.8 Hz corresponds to circumference of Earth).

Dark cyclotron photons have cyclotron energy

$$h_{eff} \times \frac{eB_{end}}{m} = \frac{GM}{v_0} \times eB_{end}$$

independent of the mass of charged particle mass, which is essential for the universality of bio-photon spectrum. The value B_{end} of the "endogenous" magnetic field introduced by Blackman should vary by say two orders of magnitude to explain the range of biophoton energies. The value of h_{eff} should be rather high.

The redshift of biophoton energy spectrum for humans as compared to lower animals could mean that the spectrum for the values of B_{end} extends to lower values. Cyclotron periods would be also longer at lower end for the spectrum. Could the higher intelligence could be achieved by better metabolic energy economy? Or could the presence of flux tubes with lower value of B_{end} extend the spectrum of biophoton energies and bring in molecules with lower transitions energies (down to near infrared)? It should be possible to identify the molecules in question.They should be involved with the "glutamate-induced biophotonic activities". The communications between brain slices could be also indirect: first sensory signal to MB is sent and response comes as control signal to other part of brain.

The value of B_{end} in Blackman's experiments (I have identified it as lower end for the spectrum of the values of B_{end}) for vertebrates was 2/5 of Earth's magnetic field B_E with nominal value of .5 Gauss. Why 2/5 rather than 1? Could this reflect that gradual reduction of B_{end} from B_E during evolution? Should one repeat the experiments of Blackman and other pioneers for non-vertebrates to find whether B_E is higher for them?

11.6.4   Dark Photons, Meditative States, And Qigong Practices

Various experiments demonstrate that meditation tends to reduce bio-photon emission [J124, J26]. The interpretation would be that for some reason meditation reduces the leakage of large $\hbar$ photons to ordinary ones. How meditation could help to achieve this reduction?

If the generation of ROS generates bio-photons by the proposed mechanism with the ordinary photon generated in ROS serving as a seed inducing the transformation of dark photons of same energy to bio-photons then reduction ROS would explain the correlation. The life style of meditator might explain why the generation of ROS is reduced. If dark photons are involved with non-destructive reading of memories and future plans (time reversed memories), and if the absorption of dark photons by laser like systems followed by a return to ground state leads to an emission of also ordinary photons then cognitive processes would generate bio-photons. In meditative practices the basic goal is to calm mind by getting rid of thoughts so that this mechanism would not produce photons anymore.

The effects of Qigong practices on bio-photon emission has been also studied. Examples are changes of bio-photon emission and temperature of human hand during Qigong [J57], the effects of mental concentration on bio-photon emission [J48], temperature and bio-photon changes of the middle finger during Qigong and light imagery tasks [J41], and comparison of bioenergy and physiological markers in qigong and acupuncture research has been carried out [J53].

Quite generally, the hands of qi healer are expected to emit bio-photons. If Qi healer generates a flux of dark photons, some fraction of them dissipates to bio-photons, so that an increase of bio-photons could be the outcome.

11.7   Dark Photons And Remote Mental Interactions

Remote mental interactions are the same interactions that relate magnetic body and biological body. Now biological body is not the "personal one" but that of target and can be also inanimate in which case the presence of codes are not expected.

1. Flux tubes serve as correlates of attention. Attention would therefore be always involved with remote mental interactions - also those between various layers magnetic body and parts

of biological body manifesting themselves in the biology of TGD Universe. Dark photons propagating along ME-flux tube pair serve as correlates of communication and control. "Motor actions" of magnetic body serve as tools of bio-control too. Also the reading of memory representations would involved dark photons and could therefore be involved with telepathy as mind reading.

2. Dark photons would accompany various remote mental interactions and the unavoidable leakage as bio-photons could be a signature of these interactions. For instance, healer generates low frequency dark photons along flux tubes creating the connection to the patient and part of these photons leak out in the process. Dark photons are expected to leak from the hands of healer as bio-photons.

3. Could simultaneous changes in bio-photon emissions from healer and healee take place and be also detected? Identical values of f_l and f_h for healer and healee would serve as as a signature. In principle testable aspect of darkness is the integer aluedness of $\hbar_{eff}/\hbar = f_h/f_l$. From quantum coherence criterion the distance roughly $L \leq c/f_l$ allows to guess upper bound for the value of f_l. The additional signature would be the identical temporal patterns of dark photons correlation functions at both ends. This would be the analog of long range temporal correlations in delayed luminescence.

4. Dark photons could be seen as universal mechanism of remote viewing. Do various sensory modalities involve separate frequency bands f_h or is the frequency band determined solely by distance? This question relevant also for brain. Second relevant question is the role of magnetic bodies. The model for the findings of Willian Tiller about intentional imprinting of electric devices [J123, J119, J120] requires that magnetic bodies serve as relay stations in this process. Both healers and healee's magnetic bodies and even those assignable to levels of collective consciousness could be involved (healing by prayer).

Chapter 12

Dark photons from transitions of dark valence electrons as origin of bio-photons, and their interaction with carcinogens

12.1   Introduction

The possible role of bio-photons in living matter is becoming gradually accepted by biologists and neuroscientists. It seems that the intensity of bio-photon emission increases in sick organisms and bio-photons are used as a diagnostic tool. Fritz Popp (see http://tinyurl.com/y7assha7) started his work with bio-photons with some observations about the interaction of UV light with carcinogens [I84] (see http://tinyurl.com/y76a9fo4). Veljckovic (http://tinyurl.com/yatedje8) has also published results suggesting correlations between carcinogenity and the absorption spectrum of photons in UV (ultraviolet).

I have proposed that bio-photons emerge as ordinary photons from what I call dark photons, which differ from ordinary photons in that they have non-standard value $h_{eff} = nh_0$ of Planck constant [K20, K30]. Also other particles - electrons, protons, ions,..., can be dark in this sense.

One of the mysteries of biology, which mere biochemistry cannot explain, is that living systems behave coherently in macroscopic scales. The TGD explanation for this is that dark particles forming Bose-Einstein condensates (BECs) and super-conducting phases at magnetic flux tubes of what I call magnetic body possess macroscopic quantum coherence due to the large value of h_{eff}. This quantum coherence would force the coherent behavior of living matter. I have already earlier developed rather concrete models for bio-photons [K20, K30] on basis of this assumption.

In the sequel I will discuss bio-photons from a new perspective by starting from bio-photon emission as a signature of a morbid condition of organism. The hypothesis is that in sick organism dark photons tend to transform to bio-photons in absence of metabolic feed increasing the value of h_{eff}. Hence BECs of dark photons and also of other dark particles decay and this leads to a loss of quantum coherence.

A further hypothesis is that at least a considerable part of bio-photons emerge in the transformations of dark photons emitted in the transitions of lonely dark valence electron of any atom able to have such. Since dark electron has a scaled up orbital radius, it sees the rest of atom as a unit charge and its spectrum is in good approximation hydrogen spectrum. Therefore the corresponding part of the spectrum of bio-photons would be universal in accordance with quantum criticality.

This picture allows to develop some ideas about quantum mechanisms behind cancer in TGD framework.

12.1.1 Some basic notions related to carcinogens

Before continuation it is good to clarify some basic notions. Toxins are poisonous substances created in metabolism. Carcinogens (`http://tinyurl.com/ybphtjqg`) are substances causing cancer, which often cause damage to DNA and induce mutations (mutagenicity).

Free radicals (see `http://tinyurl.com/y9bxoqjz`) provide a basic example about carcinogens. They have one un-paired valence electron and are therefore very reactive. The un-paired electron has a strong tendency to pair with an electron and steals it from some molecule. The molecule providing the electron is said to oxidize and free radical to act as oxidant. The outcome is a reaction cascade in which carcinogen receives electron but electron donor becomes highly reactive. Anti-oxidants stop the reaction cascade by getting oxidized to rather stable molecules (`http://tinyurl.com/omb7kc9` and `http://tinyurl.com/ydeloxcn`).

Benzo[a]pyrene (BAP) $C_{20}H_{12}$ (see `http://tinyurl.com/y8etnmwb`) is one example of carcinogen. It contains several carcinogenic rings and is formed as a product of incomplete burning and reacts with powerful oxidizers. As such BAP is not free radical but its derivatives $BAP^{\pm}$ obtained by one-electron reduction or oxidation are such (see `http://tinyurl.com/yb7am8tk`).

There are also carcinogens such as bentzene, which as such is not dangerous. What happens is that to the carbon at the ends of bentzene's double bond binds single oxygen atom and so called epoxy bond is formed. This molecule penetrates to the DNA chain and causes damage. Perhaps the fact that DNA nucleotide also contains aromatic 6-rings relates to this.

The emission of bio-photons (see `http://tinyurl.com/ol39rqx`) increases if carcinogens such as oxidants are present. The idea is that bio-photons could be relevant concerning the understanding of the problem. It has been proposed that bio-photons could be created when anti-oxidants interact with molecules generating triplet states (spin 1) which decay by photon emission. The photons generated in this way would have discrete spectrum whereas bio-photons seem to have continuous and rather featureless spectrum. Therefore this model must be taken with caution.

It could be that the origin of bio-photons is not chemical. If so, carcinogens would not produce bio-photons in ordinary atomic or molecular transitions. They could be however induce generation of bio-photons indirectly. The understanding of bio-photons might help to understand the mechanisms between carcinogenic activity. I have discussed bio-photons from TGD view in [K20, K30].

12.1.2 Some basic notions of TGD inspired quantum biology

In the sequel I try to develop a necessarily speculative picture about carcinogen action on basis of TGD based quantum about biology [K88, K112]. The goal is to develop the general theory by developing a concrete model for a problem.

Magnetic flux tube and field body/magnetic body are basic notions of TGD implied by the modification of Maxwellian electrodynamics [K88, K60, K106]. Actually a profound generalization of space-time concept is in question. Magnetic flux tubes are in well-defined sense building bricks of space-time - topological field quanta - and lead to the notion of field body/magnetic body as a magnetic field identity assignable to any physical system: in Maxwell's theory and ordinary field theory the fields of different systems superpose and one cannot say about magnetic field in given region of space-time that it would belong to some particular system. In TGD only the effects on test particle for induced fields associated with different space-time sheets with overlapping M^4 projections sum.

The hierarchy of Planck constants $h_{eff} = n \times h_0$, where h_0 is the minimum value of Planck constant, is second key notion. h_0 need not correspond to ordinary Planck constant h and both the observations of Randell Mills [L39] and the model for color vision [L59] suggest that one has $h = 6h_0$. The hierarchy of Planck constants labels a hierarchy of phases of ordinary matter behaving as dark matter.

Magnetic flux tubes would connect molecules, cells and even larger units, which would serve as nodes in (tensor-) networks [B16] [L38]. Flux tubes would also serve as correlates for quantum entanglement and replace wormholes in ER-EPR correspondence proposed by Leonard Susskind and Juan Maldacena in 2014 (see `http://tinyurl.com/y7za98cn` and `http://tinyurl.com/ydckw5u7`). In biology and neuroscience these networks would be in a central role. For instance, in brain neuron nets would be associated with them and would serve as correlates for mental

images [L42, L61]. The dynamics of mental images would correspond to that for the flux tube networks.

12.1.3   The proposed model briefly

In the sequel the basic hypothesis will be that dark photons emerging from the transitions of dark valence electrons of any atom possessing lonely unpaired valence electron could give rise to part of bio-photons in they decays to ordinary photons. The hypothesis is developed by considering a TGD based model for a finding, which served as a starting point of the work of Popp (see `http://tinyurl.com/y76a9fo4`): the irradiation of carcinogens with light at wavelength of 380 nm generates radiation with wavelength 218 nm so that the energy of the photon increases in the interaction. Also the findings of Veljkovic about the absorption spectrum of carcinogens (`http://tinyurl.com/yatedje8`) have considerably helped in the development of the model.

The outcome is a proposal for dark transitions explaining the findings of Popp and Veljkovic. The spectrum of dark photons also suggests a possible identification of metabolic energy quantum of .5 eV and of the Coulomb energy assignable to the cell membrane potential. The possible contribution to the spectrum of bio-photons is considered, and it is found that spectrum differs from a smooth spectrum since the ionization energies for dark valence electrons depending on the value of h_{eff} as $1/h_{eff}^2$ serve as accumulation points for the spectral lines. Also the possible connections with TGD based models of color vision and of music harmony (see [L59, L19, L69]) are briefly discussed.

12.2   About the modelling of the basic findings of Popp and Veljkovic

The popular article about starting point of Popp's research work (see `http://tinyurl.com/y76a9fo4`) tells that one can assign to carcinogens such as benzo[a]pyrene (polycyclic aromatic compound - a wave length $\lambda_i = 380$ nm. Carcinogen absorbs this wavelength and radiates photons with a shorter wavelength $\lambda_f = 218$ nm. In the following I try to understand what could happen in this process. I also consider the observations of Veljkovic [I144] and their relationship to the findings of Popp.

12.2.1   General TGD picture

The zeroth order iterate for TGD interpretation of the action of free radicals would be following. Free radicals lead to the destruction of dark phases with non-standard value of h_{eff}. These phases include Bose-Einstein condensates of various kinds and super-conducting phases. The process leads to an emission of dark photons which transform to ordinary photons identified as bio-photons in the phase transition $h_{eff} \to h$. For instance, this happens as vegetable ageing and bio-photon emission is indeed used as a tool to determine the age of vegetable.

How the stealing of electrons by free radical electrons could induce the negative biological effects?

1. Quantum coherence is essential for what it is to be living matter. Bio-system is full of different kinds of Bose-Einstein condensates (BECs) and superconducting phases [K89, K90]. Electronic super-conductivity is one of the most important examples. There are also cyclotron BECs for proton Cooper pairs and biologically important bosonic ions or of the Cooper pairs of fermionic ions such as Ca^{2+}, Mg^{2+}, Fe^{2+}, Na^+, K^+, Cl^-. The value of h_{eff}/h_0 for these BECs would be rather large being in the range $10^{12} - 10^{15}$. In this case h_{eff} can be identified as gravitational Planck constant h_{gr} assignable to the magnetic flux tubes mediating gravitational interaction [K104, K81, K83, K37, K38, K39, K40] [L56]. This would guarantee that cyclotron energies proportional to h_{eff} in endogenous magnetic field $B_{end} = 2/5B_E$, where $B_E = .5$ Gauss is the magnetic field of Earth, are above thermal energy at physiological temperature so that dark cyclotron photons can have biological effects.

2. Hydrogen bonds are central for the chemistry of water and living matter. The atoms able to form hydrogen bonds (O,N,...) possess so called lonely electron pair meaning that neither electron belongs to a valence bond.

   A possible TGD picture would be following. Hydrogen bond can be assigned with magnetic flux tube at which there is a delocalized proton, which can be also dark ($h_{eff} = n \times h_0 > h$). The lonely electron pair forms a Cooper pair. The electrons of the Cooper pair are at the members of a flux tube pair. Flux tubes are parallel but magnetic fluxes are in opposite directions if Cooper pair has spin 0. Spin 1 would correspond to fluxes in the same direction. Hydrogen bonds and their scaled up (by $h_{eff}/h_0 = n$) dark versions would correspond to flux tube pairs.

   The physics of water is plagued by anomalies. It has become recently clear that water must involve two phases. In TGD framework [L66] water would have dark fraction involving dark flux tubes carrying dark protons and electrons and this would allow to understand the anomalies. Intriguingly, the anomalies are strongest at physiological temperature.

3. The basic mechanism behind cancer could be following. Free radicals steal electrons and this leads to the destruction of quantum coherence as electronic Cooper pairs are destroyed and super-conductivity is lost. $h_{eff}/h_0 = n$ is reduced. This number can be regarded as a kind of IQ assignable to flux tube and one could speak about intelligence characterizing flux tube network. More precise interpretation is that the higher the value of h_{eff}/h_0 is, the higher the ability to generate conscious information is. System can also destroy information: in quantum ethics this means doing something evil!

   Remark: A little additional comment, which might irritate physicalist. TGD inspired theory of consciousness [L53] suggests strongly the emergence of ethics at fundamental quantum level. Quantum ethics is simple and universal: doing good is to increase the conscious information of the Universe about itself. This conforms with the fact that doing evil forces secrecy and the Universe loses conscious information.

   The networks formed by molecules connected by flux tubes serving as correlates for quantum entanglement decay as the Planck constant at flux tubes becomes normal and they reconnect to form short loops. The community of molecules/cells decomposes into individuals, whose basic purpose degenerates to replication. Cancer is the outcome.

4. The general picture could be that the value of h_{eff}:n is reduced due to the transitions $h_{eff,i} \rightarrow h_{eff,f} < h_{eff,i}$ induced by the free radical stealing electrons. It is quite possible that the valence electron of free radical is dark.

5. What could happen in the stealing of electron? The valence electron of carcinogen (say free radical) must be dark in order that it gets on the flux tube at which Cooper pair is. Electron could be kind of Troyan horse getting to the flux tube associated with the hydrogen bond and then would react with Cooper pair splitting it and the resulting pair of electrons would consist of ordinary ordinary electrons.

12.2.2 Basic observation

The starting point is a reaction, in which the irradiation of carcinogen produces radiation with higher photon energy. In the example consider the incoming photon has wavelength $\lambda_i = 380$ nm and energy a $E_i = 3.27$ eV, which is just at the border 3.26 eV of violet and ultraviolet. The outgoing wavelength is $\lambda_f = 218$ n, and the corresponding energy is $E_f = 5.69$ eV and therefore in UV. As such this photon does not cause harm to say DNA.

I understand this kind of reaction is rather generally occurring for carcinogens and toxins. This suggests that the action of toxins and carcinogens is universal and relies on mechanism not depending strong the molecule considered. Understanding this on basis of standard chemistry is challenging.

I also understand that the energy 3.27 eV is special in biology and might relate to the communication between cells and that carcinogenic action somehow spoils this communications. It is also known that the emission of bio-photons in presence of carcinogen increases. If these

photons are actually dark photons then dark photon BE condensate could be lost in the process and lead to a reduction of quantum coherence.

12.2.3 Possible detailed models for the observations of Popp

TGD based model for bio-catalysis assumes that catalyst and substrate are connected by flux tube or flux tube pair and that one can associate to this object a resonance frequency. One can ask whether carcinogen could act like catalyst.

Dark valence electrons behave like electrons of dark hydrogen atom

What could happen in the above process?

1. What looks strange is that the energy of final state photon is higher than initial state photon. naïvely one would expect just the opposite.

   Could it be that the atom in the initial state is - in some sense not necessarily possible in standard atomic physics - in an excited state and the absorption of incoming photons makes it even more excited state. In the final state atoms returns to ground state in some sense - not necessary that of standard atomic physics. This is like jumping upwards from balcony and dropping down.

2. Electronic excitation energies for atoms must be in question. The energy scale is however too small for the transitions of hydrogen atom and even more so for those of heavier atoms. The ground state binding energy of hydrogen atom is 13.6 eV. For other atoms the energies of inner electrons are proportional Z_{eff}^2, where Z_{eff} is the effective charge of nucleus, which is screened by electrons in full shells so that Z_{eff} is considerably reduced for valence electrons.

3. How could one understand the universality? Suppose that an unpaired valence electron is in question and that it is dark. For any atom dark valence electron has orbital radius scaled up by factor $(h_{eff}/h)^2 = (n/6)^2$ so that dark valence electron sees effective nuclear charge $Z_{eff}=1$ and behaves like an electron of hydrogen atoms apart from small corrections coming from the mass of the nucleus! In the sequel I will call any atom with one dark valence electron (or possibly even several of them) dark hydrogen atom.

4. One can therefore assume that one has effectively transitions of dark electron of hydrogen with $h_{eff}/h = n/6 > 1$. The binding energy scale would be reduced by a factor $(h/h_{eff})^2 = (n_0/n)^2 = (6/n)^2$.

   Remark: The assumption $h = n_0 \times h_0$ raises of course bewilderment. It is however quite possible that h is not the minimal value of h_{eff}. In fact, the experiments of Randel Mills suggest $h = 6h_0$ [L39]. Mills observed that hydrogen can have states for which binding energy scale is larger than normally: the would correspond to $h_{eff} = nh_0$, $n < 6$.

   Remark: Recall that carcinogens are free radicals with un-paired valence electrons. These valence electrons would be dark.

Model I

What could be the simplest model for the reaction considered? The valence electron of dark hydrogen have spin and in ground state it could be in $n_P = 1$ tilassa (n_P is principal quantum number usually denoted by n). As it absorbs photon it can go to $n_P = 1$ state with larger value of n. One could imagine a two step process

$$(n_1, n_P) = (7, 1) \rightarrow (n_2 = 8, 1) \rightarrow (n_3 = 6, 1) \ .$$

Could the incoming and outgoing energies be identified as energies for the transitions involved. The energies are 2.43 eV ja 5.95 eV. The actual values are 3.27 eV ja 5.69 eV. I have not found better fit so that Model I fails.

Model II

Let us assume a lonely dark valence electron seeing the atom effectively as hydrogen. The key observation is that $h_{eff}/h = 2$ corresponds to $n = 12 = 2 \times n_0 = 12$ with ionization energy $E_I(n = 12) = 3.4$ eV. This is not far from $E_{12} = 3.27$ eV.

Could an almost ionization from the $n = 12$ ground state with $n_P = 1$ to state $n_P = m$ occur and be followed to a state with $n < 12$ state, possibly ground state with $n_P = 1$ with an emission of photon with energy $E_{23} = 5.69$ eV $> E_{12} = 3.27$ eV? One would have $(n_i = 12, 1) \rightarrow (n_i = 12, m) \rightarrow (n_f, 1)$.

1. It is easy to see that one can have only $n_f = 9$ giving $h_{eff}/h = n_f/n_0 = n_f/6 = 3/2$. This would give ionization energy $E_I(i, n = 9) = 6.0$ eV.

2. One should have $E_{23}/E_I(n = 9) = E_{12}/E_I(n = 12) = 3.27/3.4 = .96$. The ratio of excitation energy and ground state energy would be same for initial and final state. The transition to the state $n_P = 5$ predicts $r = E_{12}/E_I(n = 12)1 - 1/25 == .96$. The prediction is correct.

   For the final state photon the prediction would be $E_{23} = (3.27/3.4) \times 6$ eV $= 5.77$ eV . The actual value is 5.69 eV. The error of the prediction is about 2 per cent.

Notice that the dark hydrogen model is extremely general and explains why so many carcinogens have this same signature. One must however notice that the orbital radius of the dark electron must be larger than that of other electrons for a screening to unit charge to take place. In the earlier applications I have assumed that the principal quantum number n_P dark valence electron is not smaller than that for the valence electrons of the ordinary atom. Also the weaker condition $n_P n > k$, where k is the principal quantum number for valence electrons, guarantees this. For hydrogen atom the condition gives no constraints but for k:th row of the periodic table one must have $n_P n > k$ (or even $n_P \geq k$). In the above model $n_P = 1$ allows only hydrogen atom. Only H and C atoms are present in carbohydrates and C has no lonely valence electrons to that the condition is automatically satisfied for them.

12.2.4   A model for the observations of Veljkovic

There is also an article of Veljkovic about carcinogens [I144] . The article tells that the wavelength range is 206-248 nm: this would correspond to the energy range 6.1-5.0 eV in UV. On the other hand, it is noticed that the most carcinogenic wavelength range is 232-278 nm, which would correspond to the energy range 5.3-4.5 eV in UV. It would seem to me that there is a mistake in the article of Veljkovic: the upper end for wavelength range should be either 248 nm or 278 nm for both ranges. Could it be that the maximal wavelength range is 206-278 nm? TGD based model supports this interpretation as will be found.

In the first table of the article 4 absorption wavelengths have been listed for the molecules appearing in it and on basis of the summary only the lowest wavelengths can be carcinogenic.

Veljkovic does not mention the wavelength 380 nm. This suggests that this wavelength is not carcinogenic as such. On basis of what has been said the transition

$$(n = 12, 380 \ nm) + X \rightarrow (n = 9, 218 \ nm) + X$$

would take place. X could be a atom in bio-molecule or in carcinogen as was assumed. It is enough that dark valence electron is in question. This process would transform dark $n = 12$ photon to dark $n = 9$ photon. $(n = 12, n_P = 1)$ dark electron would go to the intermediate state $(n = 12, n_P = 5)$ and from it to $(n = 9, n_P = 1)$ dark valence electron. The reduction of h_{eff}/h_0 would mean a reduction of "biological IQ" for both dark photons and dark electrons. Could this be enough for carcinogenic effect?

One could argue, that the any molecule containing an atom with dark $n = 12$ valence electron makes it carcinogenic. This cannot be true. Carcinogen must have some additional property. Could it be that $(n = 9, 218 \ nm)$ dark photons transforms to bio-photon, which is absorbed by the an ordinary electron of carcinogen, so that biological IQ is reduced further. The transformation to ordinary photon followed by absorption would be single quantum process. Note that the absorber could be also second carcinogen atom for which the absorbing valence electron

is ordinary. Carcinogenicity would follow from the existence of an ordinary electronic state, which can be excited by the photon produced $(n = 12, 380 \ nm) + X \rightarrow (n = 9, 218 \ nm) + X$.

Assume that the transitions are those of ordinary electrons of the carcinogen. For some value of $h_{eff}/h_0 = n$ the energy range 5.0-6.1 eV could correspond to spectral lines for dark transitions of some kind creating the absorbed photons transforming to bio-photons in absorption. One can imagine two options.

Option I: The spectral lines could coincide for those for the transitions of dark hydrogen from excited state to ground state or excited state. This model turns out to be too simple to explain the observations of Veljkovic.

Option II: The spectral lines could coincide for to those for Popp's transitions $(n = 12, n_P = 1) \rightarrow (n = 12, n_{P,i} > 1) \rightarrow n(n = 9, n_{P,f} \geq 1)$. This model can explain the observations of Veljkovic satisfactorily and suggests also a possible interpretation for the metabolic energy quantum and Coulomb energy assignable to the membrane potential. Note that only dark valence electron of hydrogen atom can be considered and this is the only possibility for hydrocarbons.

Option I

The transition energies of dark hydrogen characterized by n are given by

$$\frac{\Delta E}{E_H} = (\frac{6}{n})^2 [\frac{1}{n_{P,f}^2} - \frac{1}{n_{P,i}^2}] \ . \tag{12.2.1}$$

The simplest option is that the transition takes place to the ground state with $n_{P,f} = 1$.

For what value of $h_{eff}/h_0 = n$ energy range 5.0-6.1 eV could correspond to the spectral lines of dark hydrogen? Ionization energy for dark hydrogen gives the largest energy and it should be around $E_{max} = 6.1$ eV. If ionization does not take place, photon energy is lower and could correspond to energies in the range 5.0-6.1 eV. With these assumptions one obtains

$$E_H(n) = E_H \times (\frac{h}{h_{eff}})^2 = E_H \times (\frac{6}{n})^2 = E_{max} \ , \quad E_{max} = 6.1 \text{ eV} \ , \quad E_H = 13.6 \text{ eV} \tag{12.2.2}$$

This gives $n^2 = 80.26$ so that n is very near to $n = 9$ and $h_{eff} = 3h/2$. $n = 9$ gives upper bound $E_{max} = 6.04$ eV. Also other energies could correspond to the transitions of dark hydrogen. The transition would be of for $(n_P \rightarrow n_P = 1)$ and the energy of the emitted photon would satisfy the condition

$$\Delta E = E_{max}(1 - n_P^{-2}) = E_{min} = 5.0 \text{ eV} \ . \tag{12.2.3}$$

This would give $1/n_P^2 = 1/6$ in a reasonable approximation. This cannot be true. What if one uses as the lower bound the energy $E_{min} = 4.5$ eV, which corresponds to 278 nm. This would give $m = 2$ for $E_{max} = 6$ eV! The maximal range 206-278 nm would correspond to the emission spectrum for the transition to the ground state. Getting dark counterparts for the absorbtion energies listed by Veljkovic does not however seem probable since there is only single integer valued parameter available.

Option II

The energy of the photon is difference of $n_f = 9$ and $n_i = 12$ excitation energies characterized by $n_{P,f}$ ja $n_{P,i}$. The general formula for the transition energy ΔE allowing n_f and n_i to be arbitrary reads as

$$\Delta E = [\frac{1}{n_{P,f}^2}(\frac{6}{n_f})^2 - \frac{1}{n_{P,i}^2}(\frac{6}{n_i})^2]E_H \ . \tag{12.2.4}$$

For $n_i = 12$ with $h_{eff} = 2h$ and $n_f = 9$ with $h_{eff} = 3h/2$ one obtains the formula

$$\Delta E = [\frac{4}{9n_{P,f}^2} - \frac{1}{4n_{P,i}^2}]E_H \quad , \quad E_H = 13.6 \text{ eV} \quad . \tag{12.2.5}$$

Consider first the dependence of ΔE on n_i for given n_i.

1. Consider first the situation for $n_{P,f} = 1$.

   (a) ΔE is largest at the limit $n_{P,i} \to \infty$: this gives $\Delta E = (4/9)E_H = 6.04$ eV ($\lambda = 205$ nm), which corresponds to the upper bound for energies deducible from the results of Veljkovic. This energy is also largest possible since the scale of ΔE is proportional to $1/n_{P,f}^2$.

   (b) One obtains minimum of ΔE for for $n_{P,i} = 1$ as $\Delta E = 2.64$ eV ($\lambda = 469$ nm, blue). One therefore obtains has a band [2.64 ,6.04] eV of lines become dense at its UV end.

   (c) For $n_{P,i} = 2$ gives ($\Delta E = 5.19$ eV, $\lambda = 239$ nm). The wavelength is near to the lower bound of the wavelength range 232-278 nm mentioned by Veljkovic. For $n_{P,i} = 3$ one obtains ($\Delta E = 5.67$ eV, $\lambda = 219$ nm). The wavelength approaches to the limit 205 nm at the limit $n_{P,i} \to \infty$. The wave lengths are very densely spaced for large values of $n_{P,i}$ could well correspond in good enough approximation to the wavelengths near the lower boundary of the wavelength range given by Veljkovic.

2. $n_{P,f} = 2$ gives the upper bound $\Delta E = 1.5$ eV for ($n_{P,i} \to \infty$ in near infrared ($\lambda = 821$ nm). Lower bound $\Delta E = .67$ eV is obtained for $n_{P,i} = 2$. One has therefore band [.67,1.5] eV with density of lines getting dense in near infrared. Quite generally, for $n_{P,f} \geq 2$ ΔE is below UV range and arbitrary small values of ΔE are possible for large enough values of $n_{P,f}$.

3. $n_{P,f} = 3$ gives the upper bound $\Delta E \leq .67$ eV for ($n_{P,i} \to \infty$ and lower bound $\Delta E = .294$ eV for $n_{P,i} = 3$. Metabolic energy quantum with value of .5 eV is included in this range of energies and $n_{P,f} = 9$ gives $\Delta E = 4.45$ eV.

   Consider next the minimal values of the energy for given $n_{P,f}$.

1. The condition $\Delta E \geq 0$ gives $n_{P,f} \leq 4n_i/3$. For $(n_{P,f}, n_{P,i}) = k(4,3)$ one has $\Delta E = 0$. For $n_{P,f}$ integer nearest to but smaller than $n_{P,f} = 4n_{P,i}/3 - 1$ one has smallest value of ΔE for given $n_{P,i}$. The following formula for ΔE for $n_{P,f} = 4n_{P,i}/3 - 1$ is true for $n_{P,i} = 3k$:

$$\Delta E_{in}(n_{P,i}) = [\frac{4}{9}\frac{1}{(4k-1)^2} - \frac{1}{36k^2}]E_H \simeq \frac{E_H}{72k^3} \simeq \frac{.19 \text{ eV}}{k^3} \text{ for } k \to \infty \quad . \tag{12.2.6}$$

2. For $k = 1$ ($n_{P,i} = 3$) one obtains ($\Delta E = .66$ eV,$\lambda = 1879$ nm). ΔE is slightly higher than the nominal value .5 eV of the metabolic energy quantum.

3. For $k = 2$ ($n_{P,i} = 6$) one obtains $\Delta E = .065$ eV, which corresponds to a typical membrane potential.

To summarize, Popp transition energies of dark valence electrons of dark hydrogen atom might explain not only the energies listed by Veljkovic but also metabolic energy quantum and Josephson energy assignable to cell membrane in TGD based model of cell membrane as generalized Josephson junction.

12.2.5   Could the dark photons from Popp transitions transform to bio-photons?

Bio-photons do not seem to be produced by molecular transitions although they can induce molecular transitions about which the transitions of carcinogens would be and example. I have proposed earlier that bio-photons include dark cyclotron photons with harmonic oscillator spectrum. Spectra for several strengths of magnetic field are required to get a quasi-continuum believed to characterize bio-photons. For dark cyclotron photons also the value of $h_{eff} = h_{gr}$ would be very large [K83] [L56]. The photons emitted in the transitions of dark valence electrons with relatively small value of h_{eff} serve also as a candidate for dark photons transforming to bio-photons. They could be assigned to the parts of the magnetic body with relatively small size scale (say flux tubes connecting cells) unlike those with large value of h_{eff} and wavelengths even of order those of EEG photons.

Bio-photons include also visible wave length range. Do the transitions of dark hydrogen allow to cover this range? Besides the above kind of transitions reducing h_{eff}/h, one can also consider the transitions increasing it. One might argue that the transitions responsible for color vision are of latter type since negentropy increase is involved.

The following **Tables 12.1** and **12.2** describe the energies of emitted photons in processes $(n_i \rightarrow n_f)$ with $n_{P,i} = 1$ in the case that they are kinematically possible. n_i and n_f are allowed to vary in the range $(9, ..., 17)$ so that transitions which either increase or reduce h_{eff}/h, or leave it unaffected, are allowed.

Remark: The condition $n_{P,i}n_i > k$, where k is principle quantum number for the valence electrons of the ordinary atom guarantees the screening to unit charge. $n_{P,i} \geq k$ assumed in earlier models would be stronger condition. Similar condition must be satisfied by $n_{P,f}$: the transitions with $n_{P,i} \leq n_{P,f}$ are always possible.

1. The rows of the tables with fixed n_i give the minimum value $n_{P,f,min}$ of $n_{P,f}$ determined by the condition that the photon energy ΔE is positive, the energy ΔE_{min} in this case, and the maximum ΔE_{max} for which final state electron is free ($n_{P,f} \rightarrow \infty$. The transitions for $n_{P,f} < n_{P,f,min}$ can occur in reversal time direction as absorption.

2. By changing the roles of n_i and n_f and of $n_{P,i} = 1$ and $n_{P,f}$, the same table gives some transition energies with final state electron in the ground state ($n_{P,f} = 1$). The table also gives minimal absorption energies ΔE_{min} *resp.* maximal absorption energies ΔE_{min} as function of n_i and $n_{P,i,max}$ *resp.* $n_{P,i,max}$. Note that the transitions for $n_{P,i} < n_{P,i,min}$ for which photon energy would be negative can occur in reversal time direction as emission.

From the tables one learns that the energies of photons in visible regions can be covered by the scaled variants of the spectra but the regions near the ends have a low density of lines.

1. The densities of the spectral lines increase towards the maximal energies $\Delta E_{max}/eV \in (1.69, 1.91, 2.18, 2.5, 2.90, 3.40, 4.05, 4.90, 6.04)$ associated with $17 \geq n_i \geq 9$). The upper ends of the frequency range for $n_i + 1$ are above the lower ends for n_i so that the ranges of energies overlap. The deviation from un-evenness can be testable someday as detection technologies develop.

2. As a rule, the spectra for the transitions reducing h_{eff} begin at $n_{P,f} = 2$ since the lowest state would correspond to negative energy. The transition can be however realized in opposite direction as as a transition increasing h_{eff}. I have added to ΔE_{min} column (fourth column) the energy of this transition in brackets.

   I have added to ΔE_{min} column (fourth column) 2 spectral lines in brackets to show where the visible part of the spectrum begins in these cases. The reader can compare the spectrum to the data given about the spectrum of visible light (see `http://tinyurl.com/q8yqea9`).

   A couple of comments about the interpretation of the spectrum is in order.

1. The maximum energies for the bands intersecting visible range are $\Delta E \in (1.69, 1.91, 2.18, 2.5, 2.90, 3.40)$ labelled by $17 \geq\geq n_i \geq 12$). Note that upper end of violet is 3.26 eV and belongs to the band [2.55, 3.40] eV containing blue. Could these 6 bands becoming infinitely dense towards

their upper ends correspond to the 6 color-complement color pairs red-green, blue yellow and white-black pair included? Could different values of n_i characterize color qualia? Could the ends of the bands be identified as "nominal" wavelengths for the basic colors? Note that I have constructed a model for color vision relying on the transitions of dark electrons in [L59].

2. I have also suggested that music harmony could emerge at the level of fundamental physics [L19, L69], in particular the model for dark genetic code [L54] leads to 12-note scale. An interesting questions is whether the ratios for the frequencies associated with $\Delta E \in (1.69, 1.91, 2.18, 2.5, 2.90, 3.40)$ could correspond to simple music scale. The ratios of the energies to the smallest energy are given by $(1.00, 1.13, 1.29, 1.5, 1.72, 2.01)$. In even tempered scale with the notes of 12-note scale coming as $f_n/f_0 = 2^{n/12}$ one obtains for the pentatonic scale C,D,E,G,A,C appearing in Chinese music the frequencies ratios $(1.00, 1.12, 1.26, 1.50, 1.68, 2.00)$. The deviations are few per cent.

12.3 Possible general mechanisms for the action of carcinogen

In the following some general guesses for the effect of carcinogens are discussed and after that a model based on the findings of Popp and Veljkovic is discussed.

12.3.1 Some general ideas

Consider first some guesses.

1. The dark photons of BEC can be absorbed and reduce also reduce the value of n for dark electrons: for instance, in the above example one has $n_i = 12 \to n_f = 9$.

2. This reduction of n for catalyst and return to its original value possibly requiring metabolic energy would be the basic mechanism of bio-catalysis. It would liberate temporarily metabolic energy allowing to overcome the potential wall slowing down the reaction considered.

   Carcinogens would imitate other biomolecules in that they would have dark electrons. This might help to get into bio-molecules in this manner (consider bentzene as example). Dark lonely unpaired valence electrons would be in fundamental role. Their transitions would produce a universal spectrum playing a key role in the bio-control.

3. If 3.27 eV:n photons emerge t $n = 12$ BEC assignable to organism, the presence of carcinogen would lead to a loss of the BEC and production of bio-photons.

   If this is the case, the spectra for the transitions $(n_i, n_{P,i} \to (n_f, n_{P,f})$ of dark hydrogen atom would define the central frequencies and key energies of bio-control. There would be infinite number of these corresponding to all transitions $(n_1, n_{P,1}) \to (n_2, n_{P_2})$. Energy difference and at the same time the spectrum of biologically important photons would contain the transition energies of dark hydrogen atom:

$$E((n_i, n_{P,i} \to (n_f, n_{P,f}) = \frac{1}{n^2}\left[\frac{1}{n_f^2}\frac{1}{n_{P,f}^2} - \frac{1}{n_i^2}\frac{1}{n_{P,i}^2}\right] \times E_I(H) \ , \quad E_H = 13.6 \ eV \ . \tag{12.3.1}$$

One can say, that these spectra produce a fractal, since they are obtained from each other by scaling using rational number. Here the value of n can be such that the energies are in visible and UV range corresponding to the energy spectrum of bio-photons. The dynamics of living matter would be universal, which conforms with quantum criticality.

One could think that if molecule has in its ordinary spectrum a line coinciding with some energy in above spectrum, the molecule defines a potential carcinogen. All atoms with un-paired valence electron, which can be dark would be potential parts of carcinogen. Some additional condition must be satisfied for a molecule to be a carcinogen: the existence of ordinary transition with energy in the dark photon spectrum could be this condition. There are also other frequency spectra such as cyclotron transitions and also these could couple to carcinogens.

n_i	n_f	$n_{P,f,min}$	$\Delta E_{min}/eV$	$\Delta E_{max}/eV$
9	9	2	4.53	6.04
9	10	1	1.15 (4.82,5.50)	6.04
10	9	2	(1.15) 3.38	4.90
10	10	2	3.67	4.90
10	11	1	0.85 (3.88,4.45)	4.90
11	9	2	(2.00) 2.54	4.05
11	10	2	(0.85) 2.82	4.05
11	11	2	3.03	4.05
11	12	1	0.65 (3.20,3.67)	4.05
12	9	2	(2.64) 1.89	3.40
12	10	2	(1.50) 2.18	3.40
12	11	2	(0.65) 2.39	3.40
12	12	2	2.55	3.40
12	13	1	0.50 (2.68,3.08)	3.40
13	9	2	(3.15) 1.39	2.90
13	10	2	(2.00) 1.67	2.90
13	11	2	(1.15) 1.89	2.90
13	12	2	(0.50) 2.05	2.90
13	13	2	2.17	2.90
13	14	1	0.40 (2.27,2.62)	2.90
14	9	2	(3.55) 0.99	2.50
14	10	2	(2.40) 1.27	2.50
14	11	2	(1.55) 1.49	2.50
14	12	2	(0.90)1.65	2.50
14	13	2	(0.40) 1.77	2.50
14	14	2	1.87	2.50
14	15	1	0.32 (1.95,2.26)	2.50

Table 12.1: Table represents minimal and maximal dark photon energies $\Delta E_{min}/eV$ and $\Delta E_{max}/eV$ for transitions $(n_i, n_{P,i}) \rightarrow (n_f, n_{P,f})$ in the range $n_i \in [9, 14]$. In the column for $\Delta E_{min}/eV$ numbers in brackets give for $n_f = 1$ rows the $n_{P,i} = 2, 3$ transition energies and for $n_{P,f} = 2$ rows transition energy for the reverse transition $(1, 1) \rightarrow (1, 1)$.

n_i	n_f	$n_{P,f,min}$	$\Delta E_{min}/eV$	$\Delta E_{max}/eV$
15	9	2	(?) 0.66	2.18
15	10	2	((2.72) 0.95	2.18
15	11	2	(1.87) 1.16	2.18
15	12	2	(1.22) 1.33	2.18
15	13	2	(0.72) 1.45	2.18
15	14	2	(0.32) 1.55	2.18
15	15	2	1.63	2.18
15	16	1	0.26 (1.70,1.96)	2.18
16	9	2	(4.13) 0.40	1.91
16	10	2	(2.98) 0.69	1.91
16	11	2	(2.13) 0.90	1.91
16	12	2	(1.49) 16	1.91
16	13	2	(0.98) 1.19	1.91
16	14	2	(0.59) 1.29	1.91
16	15	2	(0.26) 1.37	1.91
16	16	2	1.43	1.91
16	17	1	0.22 (1.40,1.72)	1.91
17	9	2	(4.35) 0.18	1.69
17	10	2	(3.20) 0.47	1.69
17	11	2	(2.35) 0.68	1.69
17	12	2	(1.71) 0.84	1.69
17	13	2	1.20) 0.97	1.69
17	14	2	(0.80) 17	1.69
17	15	2	(0.48) 1.15	1.69
17	16	2	(0.22) 1.22	1.69
17	17	2	1.27	1.69
17	18	1	0.18 (1.32,1.53)	1.69

Table 12.2: Table represents minimal and maximal dark photon energies $\Delta E_{min}/eV$ and $\Delta E_{max}/eV$ for transitions $(n_i, n_{P,i}) \rightarrow (n_f, n_{P,f})$ in the range $n_i \in [15, 17]$. In the column for $\Delta E_{min}/eV$ numbers in brackets give for $n_f = 1$ rows the $n_{P,i} = 2, 3$ transition energies and for $n_{P,f} = 2$ rows transition energy for the reverse transition $(1, 1) \rightarrow (1, 1)$.

12.3.2 A proposal for the carcinogenic mechanism inspired by the observations of Popp and Veljkovic

This picture encourages to consider a rather simple mechanism for cancer as a loss of quantum coherence due to the decay of Bose-Einstein condensate of dark photons caused by the presence of carcinogen molecules. Also super conductivity possibly associated with dark valence electrons might be lost. Carcinogen would absorb the $n = 9$ dark photons ($\lambda = 218$ nm) generated from $n = 12$ dark photons (for instance for $\lambda = 380$ nm) by Popp mechanism.

Dark photon, call it A, would transform with certain rate $k_{A \to B}$ to ordinary photon (bio-photon). Bio-photon would transform with rate $k_{B \to A}$ to dark photon. Carcinogen molecule would absorb bio-photons B with rate k_C. The situation is analogous to a chemical reaction in which second components leaks out from the system by reacting with a third component, whose concentration is assumed to be large. The outcome is that both A and B approach to zero and BEC is lost.

For the densities of photons obtains the equations

$$\frac{dA}{dt} = k_{B \to A} B - k_{A \to B} A \ ,$$

$$\frac{dB}{dt} = -k_{B \to A} B + k_{A \to B} A - k_C B \ . \tag{12.3.2}$$

The equations are linear and the solution is sum of two exponent terms with rather free coefficients (A and B must be positive).

The general form for the equations is

$$\frac{dA}{dt} = k_1 B - k_2 A \ ,$$

$$\frac{dB}{dt} = -k_3 B + k_2 A \ . \tag{12.3.3}$$

One has

$$k_1 = k_{B \to A} \ , \quad k_2 = k_{A \to B} \quad k_3 = k_{B \to A} + k_C \ . \tag{12.3.4}$$

One has $k_3 > k_1$ since B is absorbed by carcinogen.

By using the ansatz

$$A = A_0 exp(-kt) \ , \quad B = B_0 exp(-kt) \ . \tag{12.3.5}$$

one obtains a homogenous linear group of two equations and the solutions for k are determined by the vanishing of the determinant of the matrix defining the group

$$k_{\pm} = \frac{k_1 + k_3}{2} \pm \frac{1}{2}\sqrt{(k_3 + k_1)^2 - 4(k_3 + k_2)k_1} \ . \tag{12.3.6}$$

The general solution is of the form

$$\begin{pmatrix} A \\ B \end{pmatrix} = \sum_{\pm} a_{\pm} exp(-k_{\pm}t) \begin{pmatrix} \frac{k_2}{k_{\pm} + k_1} \\ 1 \end{pmatrix} \ . \tag{12.3.7}$$

Both A and B approach zero with an exponential rate.

12.4   Appendix: Number theoretical characterization of the photon spectrum from dark valence electron transitions

The spectrum for the lines of dark photons from the hydrogen-like transitions of dark valence electron can be characterized number theoretically. The reason is that given transition energy is characterized by a pair (k_i, k_f) of products integers $k_i = n_i n_{P,i}$ and $k_f = n_f n_{P,f}$ as

$$\frac{\Delta E}{E_H} = \frac{1}{k_i^2} - \frac{1}{k_f^2} \quad . \tag{12.4.1}$$

For given k_i *resp.* k_f all its decompositions to a product of integers define one possible initial *resp.* final state. The spectral density is sum of energy conserving delta functions each multiplied by the number of transitions with the energy consider. This number is proportional to the product $N(k_i)N(k_f)$ for the numbers of these decompositions for k_i and k_f. The spectral density function has therefore a large value when both k_i and k_f have large number of factors.

Could the photons produced in this kind of transitions could be of special physical and biological significance? This could be the case if the number of allowed pairs (n_i, n_f) and $(n_{P,i}, n_{P,f})$ is large enough. Whether this could be the case is an open question. In any case it is interesting to look what this would imply.

One has always the decompositions $(n = 1, n_P = k)$ and $(n = k, n_P = 1)$ and for prime values of k only these decompositions exist. For non-prime values of k there are also decompositions to a product of integers different from k and 1. The number $N(k)$ of factorizations of k into a product of two integers is given by the number of different factors of k. Elementary argument showing that the number of decompositions of p^r equals to $N(p^r) = r + 1$ shows that $N(k)$ is obtained from the prime decomposition $k = \prod p_i^{r_i}$ of k as

$$N(k) = \prod_i (r_i + 1) \quad , \quad k = \prod_i p_i^{r_i} \quad . \tag{12.4.2}$$

For numbers k_i having large number of different factors the number of product decompositions is large. For prime values of k_i there are only two compositions. For instance, factorial $k = r! = 1 \times 2 ... \times r$ the number of decompositions is large. Powers $k = p^r$ have $N(k) = r+1$ decompositions. Perfect numbers $P = M_p 2^{p-1}$ ($M_p = 2^p - 1$) have large number of composition due to the large power of 2 involved.

An interesting question is, for which kind of integers the number of factors divided by integer is maximal.It is known that $N(n)$ satisfied the inequality $N(n) \leq 2^{1.5379 log(n)/log(log(n))}$ and that equation holds true for $N = 6,983,776,800$ (see `http://tinyurl.com/yar9kdfd` and `http://tinyurl.com/y7nvfce5`). I do not know whether the equation is true for some other integers. Just for fun one can look the frequency and period associated with the ground state energy of hydrogen atom with $h_{eff} = N h_0$ assuming $h = 6h_0$. The frequency is $f = (6/N)^2 (E_H/eV) \times (3/1.24)10^{14}$ Hz giving period $T = 1/f = 187.4$ h or 7.8 days, with day=24 h.

Assuming that all transitions have the same probability to appear (an assumption very probably non-realistic), one can write the spectral density function as the density of states per energy as a sum of energy conserving delta functions multiplied by the number $N(k_i)N(k_f)$ of transition with this energy

$$\frac{dN}{dE} = \sum_{k_i, k_f} N(k_i)N(k_f)\delta(E - E_{k_i \to k_f}) \quad . \tag{12.4.3}$$

Therefore the pairs (k_i, k_f) with both integers having large number of factors could be of special interest. In a more realistic treatment each delta function contains an additional weight factor telling the probability for the particular transition to occur.

Theoretical Physics

[B1] Airy functions. Available at: `https://en.wikipedia.org/wiki/Airy_function`.

[B2] Chern-Simons theory. Available at: `https://en.wikipedia.org/wiki/Chern\OT1\textendashSimons_theory`.

[B3] Elitzur–Vaidman bomb-testing problem. Available at: `https://en.wikipedia.org/wiki/Elitzur\OT1\textendashVaidman_bomb-testing_problem`.

[B4] Montonen Olive Duality. Available at: `https://en.wikipedia.org/wiki/Montonen-Olive_duality`.

[B5] No-cloning theorem. Available at: `https://en.wikipedia.org/wiki/No_cloning_theorem`.

[B6] Das A. *Integrable Models*. World Scientific, 1989.

[B7] Zee A. *The Unity of Forces in the Universe*. World Sci Press, Singapore, 1982.

[B8] Lvovsky AI. Squeezed light, 2014. Available at:`https://arxiv.org/pdf/1401.4118v1.pdf`.

[B9] Drell S Björken J. *Relativistic Quantum Fields*. Mc Graw-Hill, New York, 1965.

[B10] Rapoport D. Stochastic processes in conformal Riemann-Cartan-Weyl gravitation, 1991. Available at: `https://link.springer.com/article/10.1007/BF00675614`.

[B11] Witten E Dolan L, Nappi CR. Yangian Symmetry in $D = 4$ superconformal Yang-Mills theory, 2004. Available at: `https://arxiv.org/abs/hep-th/0401243`.

[B12] Plefka J Drummond J, Henn J. Yangian symmetry of scattering amplitudes in $\mathcal{N} = 4$ super Yang-Mills theory, 2009. Available at: `https://cdsweb.cern.ch/record/1162372/files/jhep052009046.pdf`.

[B13] Arkani-Hamed N et al. The All-Loop Integrand For Scattering Amplitudes in Planar N=4 SYM, 2010. Available at: `https://arxiv.org/abs/1008.2958`.

[B14] Bose S et al. A Spin Entanglement Witness for Quantum Gravity, 2017. Available at: `https://arxiv.org/pdf/1707.06050.pdf`.

[B15] Minev ZK et al. To catch and reverse a quantum jump mid-flight, 2019. Available at: `https://arxiv.org/abs/1803.00545`.

[B16] Preskill J et al. Holographic quantum error-correcting codes: Toy models for the bulk/boundary correspondence, 2015. Available at: `https://arxiv.org/pdf/1503.06237.pdf`.

[B17] Wang Z Freedman M, Larsen H. A modular functor which is universal for quantum computation. *Comm Math Phys*, 1(2):605–622, 2002. Available at: `https://arxiv.org/abs/quant-ph/0001108`.

[B18] Parisi G. *Field Theory, Disorder and Simulations*. World Scientific, 1992.

[B19] Huang K. *Quarks,Leptons & Gauge Fields*. World Scientific, 1982.

[B20] Reshetikhin Yu Kulish P. *J Sov Math*, 23:2345, 1983.

Biology

[I1] Alpha helix. Available at: https://en.wikipedia.org/wiki/Alpha_helix.

[I2] Asparagine Synthetase. Available at: https://www.pdb.org/pdb/files/11as.pdb.

[I3] ATP hydrolysis. Wikipedia article.Available at: https://en.wikipedia.org/wiki/ATP_hydrolysis.

[I4] Bamhi. Available at: https://www.rcsb.org/pdb/files/1bam.pdb.

[I5] Bamhi. Available at: https://rebase.neb.com/cgi-bin/seqsget?X55285.

[I6] Beta sheet. Available at: https://en.wikipedia.org/wiki/Beta_sheet.

[I7] Biophotons. Available at: https://en.wikipedia.org/wiki/Biophotons.

[I8] Brief introduction into WaveGenetics. Its scope and opporturnities. Available at: https://www.wavegenetics.jino-net.ru.

[I9] Collagen. Available at: https://en.wikipedia.org/wiki/Collagen.

[I10] DNA replication. Available at: https://en.wikipedia.org/wiki/DNA_replication.

[I11] Everywhere in a Flash: The Quantum Physics of Photosynthesis. Available at: https://www.wired.com/wiredscience/2010/02/quantum-photosynthesis/.

[I12] Fertilization. Available at: https://en.wikipedia.org/wiki/Fertilization.

[I13] Free radical theory. Available at: https://en.wikipedia.org/wiki/Free-radical_theory. See also *Free radicals and your health* t https://www.healingdaily.com/conditions/free-radicals.htm..

[I14] Genetic code. Available at: https://en.wikipedia.org/wiki/Genetic_code.

[I15] Glutathione S-transferase. Available at: https://www.pdb.org/pdb/files/14gs.pdb.

[I16] Homeopathy. Available at: https://en.wikipedia.org/wiki/Homeopathy.

[I17] Hydrolase(O-glycosyl). Available at: https://www.pdb.org/pdb/files/107l.pdb.

[I18] M. Emoto. Available at: https://www.i-sis.org.uk/water4.php.

[I19] Meiosis. Available at: https://en.wikipedia.org/wiki/Meiosis.

[I20] Mitosis. Available at: https://en.wikipedia.org/wiki/Mitosis.

[I21] Phospholipids. Available at: https://en.wikipedia.org/wiki/Phospholipids.

[I22] Pollack Laboratory- Biographical Sketch. Available at: https://faculty.washington.edu/ghp/cv/.

[I23] Polymerase chain reaction. Available at: https://en.wikipedia.org/wiki/PCR.

[I24] Protein aggregation. Available at: https://en.wikipedia.org/wiki/Protein_aggregation.

[I25] 'Psychic cells': Scientists discover cells can communicate through physical barriers. Available at: `https://newsroom.ucla.edu/portal/ucla/ucla-drew-scientists-undercover-243053.aspx`.

[I26] Quantum Mechanics Boosts Photosynthesis. Available at: `https://physicsworld.com/cws/article/news/41632`.

[I27] Secondary structures. Available at: `https://en.wikipedia.org/wiki/Secondary_structure`.

[I28] The 20 amino-acids. Available at: `https://www.people.virginia.edu/~rjh9u/aminacid.html`.

[I29] Untangling the Quantum Entanglement Behind Photosynthesis: Berkeley scientists shine new light on green plant secrets. Available at: `https://newscenter.lbl.gov/feature-stories/2010/05/10/untangling-quantum-entanglement/`.

[I30] Water has memory. Available at: `https://www.youtube.com/watch?v=ILSyt_Hhbjg`.

[I31] Xylose Isomerase. Available at: `https://www.pdb.org/pdb/files/1a0c.pdb`.

[I32] Dr. Phil Callahan on Power of Paramagnetism. *Nexus*, 2003. Available at: `https://www.nexusmagazine.com`.

[I33] Acupuncture's Molecular Effects Pinned Down: New Insights Spur Effort to Boost Treatment's Impact Significantly, 2010. Science News: `https://www.sciencedaily.com/releases/2010/05/100530144021.htm`.

[I34] Unusual Quantum Effect Discovered in Earliest Stages of Photosynthesis. *Science News*. Available at: `https://www.sciencedaily.com/releases/2012/05/120524092932.htm`, 2012.

[I35] The Fourth Phase of Water: Dr. Gerald Pollack at TEDxGuelphU, 2014. Available at: `https://www.youtube.com/watch?v=i-T7tCMUDXU`.

[I36] Sivadasan VA Bajpai RP, Kumar S. Biophoton emission on the evolution of squeezed state of frequency stable damped oscillator. *Appl Math & Comput*, 93:277–288, 1998.

[I37] Bajpai BP. Coherent nature of the radiation emitted in delayed luminescence of leaves. *J Theor Biol*, 1999.

[I38] Smith C. *Learning From Water , A Possible Quantum Computing Medium*. CHAOS, 2001.

[I39] Ingalls CE. Sensation of Hearing in Electromagnetic Fields, 2002. Available at: `https://www.angelfire.com/or/mctrl/ingalls.htm`.

[I40] McMenamin PG Chinnery HR, Pearlman E. Cutting Edge: Membrane Nanotubes In Vivo: A Feature of MHC Class II+ Cell s in the Mouse Cornea. *J Immunol*, 180:5779–5783, 2008.

[I41] Murogoki P Comorosan S, Hristea M. On a new symmetry in biological systems. *Bull Math Biol*, page 107, 1980.

[I42] Rodgers CT and Hore PJ. Chemical magnetoreception in birds: The radical pair mechanism. *PNAS*, 106:353–360, 2016. Available at: `https://tinyurl.com/zsg4b95`.

[I43] Robson D. Researchers Seek to Demystify the Metabolic Magic of Sled Dogs, 2008. Available at: `https://tinyurl.com/o4o8srm`.

[I44] Woodbury DJ. Pure lipid vesicles can induce channel-like conductances in planar bilayers., 1989.

[I45] Clayton DL. Circadian and geotactic behaviors: Genetic pleiotropy in *drosophila melanogaster*. *Journal of Circadian Rhytms*, 12(1):1–5, 2016. Available at: `https://dx.doi.org/10.5334/jcr.140`.

[I46] Tedeschi Alberto Emilio Del Giudice, Paola Rosa Spinetti. Article: Water Dynamics at the Root of Metamorphosis in Living Organisms. *Water*, 2:566–586, 2010. Available at: `https://www.mdpi.com/journal/water`.

[I47] Alberts B et al. *Mol Biol Cell* . Garland Publishing, Inc., London, 1989.

[I48] Benveniste J et al. Human basophil degranulation triggered by very dilute antiserum against IgE. *Nature*, 333:816–818, 1988.

[I49] Benveniste J et al. Transatlantic transfer of digitized antigen signal by telephone link. *J Allergy and Clinical Immunology*, 99:175, 1989. Available at: `https://www.digibio-.com/`.

[I50] Bonora M et al. ATP synthesis and storage. *Purinergic Signal*, 8(3):343–357, 2012. Available at: `https://pubmed.ncbi.nlm.nih.gov/22528680/`.

[I51] Diaz-Colunga J et al. Global epistasis on fitness landscapes. *Philosophical Transactions of the Royal Society B. Biological Sciences*, 2023. Available at: `https://doi.org/10.1098/rstb.2022.0053`.

[I52] Dotta BT et al. Biophoton emissions from cell cultures: biochemical evidence for the plasma membrane as the primary source. *Gen Physiol Biophys*, 30(3):301–309, 2011.

[I53] Gariaev P et al. *The DNA-wave biocomputer*, volume 10. CHAOS, 2001.

[I54] Gariaev PP et al. Holographic Associative Memory of Biological Systems. *Proceedings SPIE - The International Soc for Opt Eng . Optical Memory and Neural Networks*, pages 280–291, 1991.

[I55] Gariaev PP et al. The spectroscopy of bio-photons in non-local genetic regulation. *J Non-Locality and Remote Mental Interactions*, (3), 2002. Available at: `https://www.emergentmind.org/gariaevI3.htm`.

[I56] Goldman N et al. Adenosine A1 receptors mediate local anti-nociceptive effects of acupuncture. *Nature Neuroscience*, 13:883–888, 2010. . Available at: `https://www.nature.com/neuro/journal/v13/n7/full/nn.2562.html`.

[I57] Haussmann IU et al. CMTr cap-adjacent 2'-O-ribose mRNA methyltransferases are required for reward learning and mRNA localization to synapses. *Nature Communications*, 13(1), 2022. Available at: `https://www.nature.com/articles/s41467-022-28549-5`.

[I58] Kataoka Y et al. Activity-Dependent Neural Tissue Oxidation Emits Intrinsic Ultraweak Photons. *Biochem & Biophys Res Comm*, 285(4):1007–1011, 2001.

[I59] Kazumov AYu et al. Proximity-Induce super-conductivity in DNA. *Science*, 291, 2001.

[I60] Klumpe H et al. The context-dependent, combinatorial logic of BMP signaling, 2020. Available at: `https://www.biorxiv.org/content/10.1101/2020.12.08.416503v1`.

[I61] Krasnokutski et al. A pathway to peptides in space through the condensation of atomic carbon, 2022. Available at: `https://arxiv.org/abs/2202.12170`.

[I62] Lev AA et al. Rapid switching of ion current in narrow pores: implications for biological ion channels. *Proc R Soc London. Series B: Biological Sci s*, pages 187–192, 1993.

[I63] Lin JC et al. The Micro-wave Auditive phenomenon. *Proceedings of the IEEE*, 68, 1980.

[I64] Ling GN et al. Experimental confirmation, from model studies, of a key prediction of the polarized multilayer theory of cell water. *Physiological Chem & Phys*, 10(1):87–88, 1978.

[I65] Montagnier L et al. Electromagnetic Signals Are Produced by Aqueous Nanostructures Derived from Bacterial DNA Sequences. *Interdiscip Sci Comput Life Sci* . Available at: `https://www.springerlink.com/content/0557v31188m3766x/`, 2009.

[I66] Montagnier L et al. DNA waves and water, 2010. Available at: `https://arxiv.org/abs/1012.5166`.

[I67] Montagnier Y et al. Water Bridging Dynamics of Polymerase Chain Reaction in the Gauge Theory Paradigm of Quantum Fields. *Water*, 9(5), 2017. Available at: `https://www.mdpi.com/2073-4441/9/5/339`.

[I68] Perry et al. Mitochondrial membrane potential probes and the proton gradient: a practical usage guide. *BioTechniques*, 50(2), 2018. Available at: `https://www.future-science.com/doi/10.2144/000113610`.

[I69] Pezo V et al. Noncanonical DNA polymerization by aminoadenine-based siphoviruses. *Science*, 372(6541), 2021. Available at: `https://www.science.org/doi/10.1126/science.abe6542`.

[I70] Popp et al. Biophoton emission. New evidence for coherence and DNA as source. *Biophys*, 6(1):33–52, 1984.

[I71] Popp F-A et al. Emission of Visible and Ultraviolet Radiation by Active Biological Systems. *Collective Phenomena*, 3, 1981.

[I72] Popp F-A et al. Physical aspects of biophotons. *Experientia*, 44(7):576–585, 1988.

[I73] Popp F-A et al. Evidence of non-classical (squeezed) light in biological systems. *Phys Lett A*, 293(4):98–102, 2002.

[I74] Purves D et al. *What are basal ganglia?* 2001. August. Available at: `https://www.neuroscientificallychallenged.com/blog/what-are-basal-ganglia`.

[I75] Rahnama M et al. Emission of mitochondrial biophotons and their effect on electrical activity of membrane via microtubules. *J Integr NeuroSci*. Available at: `https://arxiv.org/pdf/1012.3371.pdf`, 1:65–88, 2009.

[I76] Sataric MV et al. Modelling the role of intrinsic electric fields in microtubules as an additional control mechanism of bi-directional intracellular transport. *Biochem Biophys*, 52:113–124, 2008.

[I77] Steinier YR et al. Genetic compensation induced by deleterious mutations but not gene knockdowns. *Nature*, 2015. Available at: `https://doi.org/10.1038/nature14580`.

[I78] Vaibhav Mohanty et al. Maximum mutational robustness in genotype–phenotype maps follows a self-similar blancmange-like curve. *Journal of The Royal Society Interface*, 2023. Available at: `rebrand.ly/zrzfgoy`.

[I79] Wang Z et al. Human high intelligence is involved in spectral redshift of biophotonic activities in the brain. *Proc Nat Acad Sci of USA*, 2016. Available at: `https://tinyurl.com/j5vusyy`.

[I80] Yoshii T et al. Cryptochrome mediates light-dependent magnetosensitivity of drosophila's circadian clock. *PLoS Biol*, 7(4), 2009. Available at: `https://tinyurl.com/zvlmxp6`.

[I81] Zerulla K et al. Dna as a phosphate storage polymer and the alternative advantages of polyploidy for growth or survival. *PLOS one*, 9(4), 2014.

[I82] Zhang Y et al. The radical pair mechanism and the avian chemical compass: Quantum coherence and entanglement, 2015. Available at: `https://tinyurl.com/zvcguuz`..

[I83] Popp F-A. Properties of biophotons and their theoretical implications. *Indian J Exp Biol*, 41(5):391–402, 2003.

[I84] Popp FA. Electronic structure and carcinogenic activity of 3,4-benzopyrene and 1,2-benzopyrene. *Z Naturforsch B.*, 27(7):850–863, 1972.

[I85] Popp FA. Cancer growth and its inhibition in terms of coherence. *Electromagn Biol Med*, 28(1):53–60, 2009.

[I86] Schönenberger C Fink H-W. Electrical conduction through DNA molecules. *Nature*, 398, 1999.

[I87] Cheng Y-C Fleming GR, Lee H. Coherence Dynamics in Photosynthesis: Protein Protection of Excitonic Coherence. *Science*, 316(5830):1462–1465, 2007. Available at: `https://www.nature.com/ejhg/journal/v10/n11/index.html`.

[I88] Bludorf F Fozar G. Scientists prove DNA Can Be Reprogrammed by Words and Frequencies, 2014.

[I89] Ling G. Three sets of independent disproofs against the membrane-pump theory, 1978. Available at: `https://www.gilbertling.org/lp6a.htm`.

[I90] Ling G. Oxidative phosphorylation and mitochondrial physiology: a critical review of chemiosmotic theory and reinterpretation by the association-induction hypothesis. *Physiol. Chem. & Physics*, 13, 1981.

[I91] Pollack G. *Cells, Gels and the Engines of Life.* Ebner and Sons, 2000. Available at: `https://www.cellsandgels.com/`.

[I92] Pollack G. *Cells, Gels and the Engines of Life.* Ebner and Sons, 2000. Available at: `https://www.cellsandgels.com/`.

[I93] Vassilatos G. Nocturnal Disturbances and the Infrasonic "HUM", 2001. Available at: `https://www.borderlands.com/journal/nux.htm`.

[I94] Maslow MU Gariaev PP. Fractal Presentation of Natural Language Texts and Genetic Code, 2nd International Conference on Quantitative Linguistics. *QUALICO '94*, pages 193–194, 1994.

[I95] Tovmash AV Gariaev PP, Tertishni GG. Experimental investigation in vitro of holographic mapping and holographic transposition of DNA in conjuction with the information pool encircling DNA. *New Medical Technologies*, 9:42–53, 2007.

[I96] Ling GN. *A physical theory of the living state: the association-induction hypothesis; with considerations of the mechanics involved in ionic specificity.* Blaisdell Pub. Co., New York, 1962.

[I97] Ling GN. Maintenance of low sodium and high potassium levels in resting muscle cells. *J Physiol (Cambridge)*, pages 105–123, 1978.

[I98] Turberfield J A Green SJ, Lubrich D. DNA Hairpins: Fuel for Autonomous DNA Devices. *Biophys J*, 2006. Available at: `https://findarticles.com/p/articles/mi_qa3938/is_200610/ai_n16779588/pg_1`.

[I99] Burr H. *The fields of life.* New York: Ballantine, 1972.

[I100] Fröhlich H. The extraordinary dielectric properties of biological materials and the action of enzymes. *Nature*, 72(1968):641–649, 1975.

[I101] Mae-Wan Ho. Super-Conducting Liquid Crystalline Water Aligned with Collagen Fibres in the Fascia as Acupuncture Meridians of Traditional Chinese Medicine. *Forum on immunopathological diseases and therapeutics*, 3(3-4):221–236, 2012. Available at: `https://dl.begellhouse.com/journals/1a654bf03faf67ac,744ec0d724b32947.html`.

[I102] Saunders PT Ho M-W. *Liquid Crystalline Mesophase in living organisms.* World Scientific, Singapore, 1994.

[I103] Kominis IK. The radical-pair mechanism as a paradigm for the emerging science of quantum biology, 2015. Available at: `https://arxiv.org/abs/1512.00450.`.

[I104] Slavinski J. Biophotons from stressed and dying organisms: toxicological aspects. *Indian J Exp Biol*, 41(5):483–493, 2003.

[I105] Brizhik L. Nonlinear mechanism for weak photon emission from biosystems. *Indian J Exp Biol*, 46(5):353–357, 2008.

[I106] McTaggart L. *The Field*. HarperCollinsPublishers Ltd. Available at: `https:/www.torsioelement.com.`, 2001.

[I107] Sanduloviciu M Lozneanu E. Minimal-cell system created in laboratory by self-organization. *Chaos , Solitons & Fractals*, 18(2):335, 2003. See also *Plasma blobs hint at new form of life*. New Scientist vol. 179, No. 2413 p. 20 September 2003, page 16.

[I108] Buchanan M. Shape is all. *New Scientist*, 2157, 1998.

[I109] Emoto M. *Crystal Clear – Messages from Water*. Beyond Worlds, 2005. Available at: `https://www.libristo.eu/en/book/hidden-messages-in-water_09269861`.

[I110] Levin M. The wisdom of the body: future techniques and approaches to morphogenetic fields in regenerative medicine, developmental biology and cancer. *Regen Med .* Available at: `https://www.futuremedicine.com/doi/pdf/10.2217/rme.11.69`, 6(6):667–673, 2011.

[I111] Levin M. Morphogenetic fields in embryogenesis, regeneration, and cancer: Non-local control of complex patterning. *Biosystems*, 109(3):243–261, 2012. Available at: `https://www.ncbi.nlm.nih.gov/pubmed/22542702`.

[I112] Ho M-W. *The Rainbow and the Worm*. World Scientific, Singapore, 1993.

[I113] Ho M-W. Genes don't Generate Body Patterns, 2011. Available at: `https://www.i-sis.org.uk/Genes_dont_Generate_Body_Patterns.php`.

[I114] Ho M-W. Mystery of Missing Heritability Solved, 2011. Available at: `https://www.i-sis.org.uk/Mystery_of_Missing_Heritability_Solved.php`.

[I115] Ho M-W. No Genes for Intelligence in the Human Genome, 2011. Available at: `https://www.i-sis.org.uk/No_Genes_for_Intelligence_in_the_Human_Genome.php`.

[I116] Ho M-W. Proteins secret water music in nanospace, 2011. Available at: `https://www.i-sis.org.uk/Proteins_secret_water_music_in_nanospace.php`.

[I117] Ho M-W. Quantum Coherent Water Homeopathy, 2011. Available at: `https://www.i-sis.org.uk/Quantum_Coherent_Water_Homeopathy.php`.

[I118] Volodyaev Ilya Mayburov SN. Photons Production and Communications in Biological Systems. *Progress In Electromagnetics Research Symposium Abstracts*, 2009.

[I119] Stevens MJ. Simple Simulations of DNA Condensation. *Biophys. J.*, 80(1):130–139, 2001. Available at: `https://www.biophysj.org/cgi/content/full/80/1/130#E8`.

[I120] Volkenstein MV. *Biophysics*. Mir Publishers, Moscow, 1983.

[I121] Ho MW. *The Rainbow and the Worm*. World Scientific, Singapore, 1993.

[I122] Rattemayer M Nagl W, Popp F-A. Evidence of Photon Emission from DNA in Living Systems. *Naturwissenschaften*, 68(5):577, 1981.

[I123] Nwamba OC. Membranes as the third genetic code. *Mol Biol Rep*, 47(5):4093–4097, 2020. Available at: `https://pubmed.ncbi.nlm.nih.gov/32279211/`.

[I124] Gariaev P. Materialization of DNA Fragment and Wave Genetics in Theory and Practice. *DNADJ*, 4(1), 2014. Available at: `https://www.amazon.com/Decipher-Journal-Volume-Issue-Materialization/dp/1500127493`.

[I125] England J Perunov N, Marsland R. Statistical Physics of Adaptation, 2014. Available at: `https://arxiv.org/pdf/1412.1875v1.pdf`.

[I126] Zhao Q Pollack GH, Figueroa X. Molecules, water, and radiant energy: new clues for the origin of life. *Int J Mol Sci*, 10:1419–1429, 2009. Available at: `https://tinyurl.com/ntkfhlc`.

[I127] Callahan PS. Moth and Candle: the Candle Flame as a Sexual Mimic of the Coded Infrared Wavelengths from a Moth Sex Scent. *Appl Opt*, 16(12), 1977.

[I128] Orians GH Purves WK. *Life: The Sci of Biology.* Sinauer, Massachusetts, 1987.

[I129] Sheldrake R. *A New Science of Life: The Hypothesis of Formative Causation.* Inner Traditions Intl Ltd., 1995.

[I130] Sheldrake R. *The Presence of Past: Morphic Resonance and the Habits of Nature* . Icon Books Ltd, 2011.

[I131] Pospisil P Rastogi A. Effect of exogenous hydrogen peroxide on biophoton emission from radish root cells. *Plant Physiol & Biochem*, 48:117–123, 2010.

[I132] Pospisil P Rastogi A. Ultra-weak photon emission as a non-invasive tool for monitoring of oxidative processes in the epidermal cells of human skin: comparative study on the dorsal and palm side of the hand. *Skin Res & Tech*, 16:365–370, 2010.

[I133] Bajpai RP. Coherent Nature of the Radiation Emitted ion Delayed Luminescence of Leaves. *J. Theor. Biol.*, 93:287–299, 1999.

[I134] Bajpai RP. Squeezed state description of spectral decompositions of a biophoton signal. *Phys Lett*, A 337:265–273, 2005.

[I135] Comorosan S. On a possible biological spectroscopy. *Bull Math Biol*, page 419, 1975.

[I136] Rackovsky S. On the nature of the protein folding code. *Proc Natl Acad Sci USA*, 90(2), 1993. Available at: `https://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=45720`. See also *Protein folding* at `https://en.wikipedia.org/wiki/Protein_folding`.

[I137] Qin F Sachs F. Gated, ion-selective channels observed with patch pipettes in the absence of membranes: novel properties of a gigaseal. *Biophys J*, pages 1101–1107, 1993.

[I138] Neher B Sakmann B. *Single-channel recording.* Plenum, London, 1983.

[I139] Tshitshinadze G Shaduri M. On the problem of application of Bioenergography in medicine. *Georgian Eng News*, 2, 1999.

[I140] Rau DC Sidorova NY. Differences between EcoRI Nonspecific and "Star" Sequence Complexes Revealed by Osmotic Stress. *Biophys J* . Available at: `https://www.biophysj.org/cgi/content/full/87/4/2564`, 87, 2004.

[I141] Levin M Somrat T. An automated training paradigm reveals long-term memory in planarians and its persistence through head regeneration. *The J Experimental Biology*, 216:3799–3810, 2013. Available at: `https://tinyurl.com/ntlxpep`.

[I142] Creighton TE. *Proteins: Structures and Molecular Properties.* Freeman, New York, 1993.

[I143] Karu TI. *The Sci of Low-Power Laser Therapy.* Gordon and Breach, Sci. Publ.. Available at: `https://www.laserhealthsystems.com/Dr.%20Tiina%20Karu%20Presentation.htm`, London, 1998.

[I144] Veljkovic V and Lalovic DI. Correlation between the carcinogenicity of organic substances and their spectral characteristics. *Experientia*, 34(10):1342–1343, 1978.

[I145] Vergara C Villar PS and Bacigalupo J. Energy sources that fuel metabolic processes in protruding finger-like organelles. *FEBS Journal*, 2020. Available at: `https://doi.org/10.1111/febs.15620`.

[I146] Merali Z. Water gave life on Earth a guiding hand. *New Scientist*, 2540:25, 2006.

[I147] Pollack GH Zheng J-M. Long-range forces extending from polymer-gel surfaces. *Phys Rev E*, 68:031408–, 2003. Available at: `https://tinyurl.com/ntkfhlc`.

Books related to TGD

[K1] Pitkänen M Gariaev P. Model for the Findings about Hologram Generating Properties of DNA. In *Genes and Memes: Part I. https://tgdtheory.fi/tgdhtml/Bgenememe1.html*. Available at: https://tgdtheory.fi/pdfpool/dnahologram.pdf, 2023.

[K2] Pitkänen M. Hydrodynamics and CP_2 Geometry. In *TGD and Condensed Matter. https://tgdtheory.fi/tgdhtml/BTGDcondmat.html*.

[K3] Pitkänen M. *Topological Geometrodynamics.* 1983. Thesis in Helsinki University 1983.

[K4] Pitkänen M. *Life and Consciousness: TGD based vision.* Lambert. Available at: https://tinyurl.com/zn98vka., 2014.

[K5] Pitkänen M. DNA as Topological Quantum Computer. In *Quantum - and Classical Computation in TGD Universe. https://tgdtheory.fi/tgdhtml/Btgdcomp.html*. Available at: https://tgdtheory.fi/pdfpool/dnatqc.pdf, 2015.

[K6] Pitkänen M. Topological Quantum Computation in TGD Universe. In *Quantum - and Classical Computation in TGD Universe. https://tgdtheory.fi/tgdhtml/Btgdcomp.html*. Available at: https://tgdtheory.fi/pdfpool/tqc.pdf, 2015.

[K7] Pitkänen M. *Topological Geometrodynamics: Revised Edition.* Bentham.Available at: https://tinyurl.com/h26hqul., 2016.

[K8] Pitkänen M. Philosophy of Adelic Physics. In *TGD as a Generalized Number Theory: Part I. https://tgdtheory.fi/tgdhtml/Btgdnumber1.html*. Available at: https://tgdtheory.fi/pdfpool/adelephysics.pdf, 2017.

[K9] Pitkänen M. Some comments related to Zero Energy Ontology (ZEO). In *TGD and Nuclear Physics. https://tgdtheory.fi/tgdhtml/Bnucl.html*. Available at: https://tgdtheory.fi/pdfpool/zeoquestions.pdf, 2019.

[K10] Pitkänen M. A Model for Protein Folding and Bio-catalysis. In *TGD and Quantum Biology: Part I. https://tgdtheory.fi/tgdhtml/Bqbio1.html*. Available at: https://tgdtheory.fi/pdfpool/foldcat.pdf, 2023.

[K11] Pitkänen M. A Possible Explanation of Shnoll Effect. In *TGD and Fringe Physics. https://tgdtheory.fi/tgdhtml/Bfreenergies.html*. Available at: https://tgdtheory.fi/pdfpool/ShnollTGD.pdf, 2023.

[K12] Pitkänen M. About Concrete Realization of Remote Metabolism. In *TGD and Fringe Physics. https://tgdtheory.fi/tgdhtml/Bfreenergies.html*. Available at: https://tgdtheory.fi/pdfpool/remotetesla.pdf, 2023.

[K13] Pitkänen M. About Nature of Time. In *TGD Inspired Theory of Consciousness: Part I. https://tgdtheory.fi/tgdhtml/Btgdconsc1.html*. Available at: https://tgdtheory.fi/pdfpool/timenature.pdf, 2023.

[K14] Pitkänen M. About Preferred Extremals of Kähler Action. In *Physics in Many-Sheeted Space-Time: Part I. https://tgdtheory.fi/tgdhtml/Btgdclass1.html*. Available at: https://tgdtheory.fi/pdfpool/prext.pdf, 2023.

[K15] Pitkänen M. About Strange Effects Related to Rotating Magnetic Systems . In *TGD and Fringe Physics. https: // tgdtheory. fi/ tgdhtml/ Bfreenergies. html* . Available at: https://tgdtheory.fi/pdfpool/Faraday.pdf, 2023.

[K16] Pitkänen M. About TGD counterparts of twistor amplitudes. In *Quantum TGD: Part III. https: // tgdtheory. fi/ tgdhtml/ Btgdquantum3. html* . Available at: https://tgdtheory.fi/pdfpool/twisttgd.pdf, 2023.

[K17] Pitkänen M. About the New Physics Behind Qualia. In *Bio-Systems as Self-Organizing Quantum Systems. https: // tgdtheory. fi/ tgdhtml/ BbioSO. html* . Available at: https://tgdtheory.fi/pdfpool/newphys.pdf, 2023.

[K18] Pitkänen M. About the Nottale's formula for h_{gr} and the possibility that Planck length l_P and CP_2 length R are related. In *Dark Matter and TGD: https: // tgdtheory. fi/ tgdhtml/ Bdark. html* . Available at: https://tgdtheory.fi/pdfpool/vzerovariableG.pdf, 2023.

[K19] Pitkänen M. About twistor lift of TGD? In *Quantum TGD: Part III. https: // tgdtheory. fi/ tgdhtml/ Btgdquantum3. html* . Available at: https://tgdtheory.fi/pdfpool/hgrtwistor.pdf, 2023.

[K20] Pitkänen M. Are dark photons behind biophotons? In *TGD and Quantum Biology: Part I. https: // tgdtheory. fi/ tgdhtml/ Bqbio1. html* . Available at: https://tgdtheory.fi/pdfpool/biophotonslian.pdf, 2023.

[K21] Pitkänen M. Basic Properties of CP_2 and Elementary Facts about p-Adic Numbers. In *Quantum TGD: Part I. https: // tgdtheory. fi/ tgdhtml/ Btgdquantum1. html* . Available at: https://www.tgdtheory.fi/public_html/pdfpool/append.pdf, 2023.

[K22] Pitkänen M. *Bio-Systems as Conscious Holograms*. Online book. Available at: https://www.tgdtheory.fi/tgdhtml/holography.html., 2023.

[K23] Pitkänen M. Bio-Systems as Conscious Holograms. In *TGD Universe as a Conscious Hologram. https: // tgdtheory. fi/ tgdhtml/ Bholography. html* . Available at: https://tgdtheory.fi/pdfpool/hologram.pdf, 2023.

[K24] Pitkänen M. *Bio-Systems as Self-Organizing Quantum Systems*. Online book. Available at: https://www.tgdtheory.fi/tgdhtml/bioselforg.html., 2023.

[K25] Pitkänen M. Bio-Systems as Super-Conductors: Part I. In *Bio-Systems as Self-Organizing Quantum Systems. https: // tgdtheory. fi/ tgdhtml/ BbioSO. html* . Available at: https://tgdtheory.fi/pdfpool/superc1.pdf, 2023.

[K26] Pitkänen M. Bio-Systems as Super-Conductors: part II. In *Bio-Systems as Self-Organizing Quantum Systems. https: // tgdtheory. fi/ tgdhtml/ BbioSO. html* . Available at: https://tgdtheory.fi/pdfpool/superc2.pdf, 2023.

[K27] Pitkänen M. Biological Realization of Self Hierarchy. In *Bio-Systems as Self-Organizing Quantum Systems. https: // tgdtheory. fi/ tgdhtml/ BbioSO. html* . Available at: https://tgdtheory.fi/pdfpool/bioselfc.pdf, 2023.

[K28] Pitkänen M. Classical TGD. In *Topological Geometrodynamics: Overview: Part I:https: // tgdtheory. fi/ tgdhtml/ Btgdview1. html* . Available at: https://tgdtheory.fi/pdfpool/tgdclass.pdf, 2023.

[K29] Pitkänen M. Cold Fusion Again. In *TGD and Nuclear Physics. https: // tgdtheory. fi/ tgdhtml/ Bnucl. html* . Available at: https://tgdtheory.fi/pdfpool/coldfusionagain.pdf, 2023.

[K30] Pitkänen M. Comments on the recent experiments by the group of Michael Persinger. In *TGD and EEG: Part I. https: // tgdtheory. fi/ tgdhtml/ Btgdeeg1. html* . Available at: https://tgdtheory.fi/pdfpool/persconsc.pdf, 2023.

[K31] Pitkänen M. Comparing Berry phase model of super-conductivity with TGD based model. In *TGD and Condensed Matter. https://tgdtheory.fi/tgdhtml/BTGDcondmat.html*. Available at: https://tgdtheory.fi/pdfpool/SCBerryTGD.pdf, 2023.

[K32] Pitkänen M. Comparison of TGD inspired theory of consciousness with some other theories of consciousness. In *TGD Inspired Theory of Consciousness: Part II. https://tgdtheory.fi/tgdhtml/Btgdconsc2.html*. Available at: https://tgdtheory.fi/pdfpool/consccomparison.pdf, 2023.

[K33] Pitkänen M. Construction of elementary particle vacuum functionals. In *p-Adic Physics. https://tgdtheory.fi/tgdhtml/Bpadphys.html*. Available at: https://tgdtheory.fi/pdfpool/elvafu.pdf, 2023.

[K34] Pitkänen M. Construction of Quantum Theory: M-matrix. In *Quantum TGD: Part I. https://tgdtheory.fi/tgdhtml/Btgdquantum1.html*. Available at: https://tgdtheory.fi/pdfpool/towards.pdf, 2023.

[K35] Pitkänen M. Construction of WCW Kähler Geometry from Symmetry Principles. In *Quantum Physics as Infinite-Dimensional Geometry. https://tgdtheory.fi/tgdhtml/Btgdgeom.html*. Available at: https://tgdtheory.fi/pdfpool/compl1.pdf, 2023.

[K36] Pitkänen M. Could Genetic Code Be Understood Number Theoretically? In *Genes and Memes: Part I. https://tgdtheory.fi/tgdhtml/genememe1.html*. Available at: https://tgdtheory.fi/pdfpool/genenumber.pdf, 2023.

[K37] Pitkänen M. Criticality and dark matter: part I. In *Dark Matter and TGD: https://tgdtheory.fi/tgdhtml/Bdark.html*. Available at: https://tgdtheory.fi/pdfpool/qcritdark1.pdf, 2023.

[K38] Pitkänen M. Criticality and dark matter: part II. In *Dark Matter and TGD: https://tgdtheory.fi/tgdhtml/Bdark.html*. Available at: https://tgdtheory.fi/pdfpool/qcritdark2.pdf, 2023.

[K39] Pitkänen M. Criticality and dark matter: part III. In *Dark Matter and TGD: https://tgdtheory.fi/tgdhtml/Bdark.html*. Available at: https://tgdtheory.fi/pdfpool/qcritdark3.pdf, 2023.

[K40] Pitkänen M. Criticality and dark matter: part IV. In *Dark Matter and TGD: https://tgdtheory.fi/tgdhtml/Bdark.html*. Available at: https://tgdtheory.fi/pdfpool/qcritdark4.pdf, 2023.

[K41] Pitkänen M. Crop Circles and Life at Parallel Space-Time Sheets. In *Magnetospheric Consciousness. https://tgdtheory.fi/tgdhtml/Bmagnconsc.html*. Available at: https://tgdtheory.fi/pdfpool/crop1.pdf, 2023.

[K42] Pitkänen M. Crop Circles and Life at Parallel Space-Time Sheets. In *Magnetospheric Consciousness. https://tgdtheory.fi/tgdhtml/Bmagnconsc.html*. Available at: https://tgdtheory.fi/pdfpool/crop2.pdf, 2023.

[K43] Pitkänen M. Dark Forces and Living Matter. In *Bio-Systems as Self-Organizing Quantum Systems. https://tgdtheory.fi/tgdhtml/BbioSO.html*. Available at: https://tgdtheory.fi/pdfpool/darkforces.pdf, 2023.

[K44] Pitkänen M. Dark Matter Hierarchy and Hierarchy of EEGs. In *TGD and EEG: Part I. https://tgdtheory.fi/tgdhtml/Btgdeeg1.html*. Available at: https://tgdtheory.fi/pdfpool/eegdark.pdf, 2023.

[K45] Pitkänen M. Dark Nuclear Physics and Condensed Matter. In *TGD and Nuclear Physics. https://tgdtheory.fi/tgdhtml/Bnucl.html*. Available at: https://tgdtheory.fi/pdfpool/exonuclear.pdf, 2023.

[K46] Pitkänen M. Does TGD Predict a Spectrum of Planck Constants? In *Dark Matter and TGD: https://tgdtheory.fi/tgdhtml/Bdark.html*. Available at: https://tgdtheory.fi/pdfpool/Planck, 2023.

[K47] Pitkänen M. Evolution in Many-Sheeted Space-Time: Part I. In *Evolution in TGD Universe. https://tgdtheory.fi/tgdhtml/Btgdevolution.html*. Available at: https://tgdtheory.fi/pdfpool/prebio1.pdf, 2023.

[K48] Pitkänen M. Evolution in Many-Sheeted Space-Time: Part II. In *Evolution in TGD Universe. https://tgdtheory.fi/tgdhtml/Btgdevolution.html*. Available at: https://tgdtheory.fi/pdfpool/prebio2.pdf, 2023.

[K49] Pitkänen M. From Principles to Diagrams. In *Quantum TGD: Part III. https://tgdtheory.fi/tgdhtml/Btgdquantum3.html*. Available at: https://tgdtheory.fi/pdfpool/diagrams.pdf, 2023.

[K50] Pitkänen M. General Theory of Qualia. In *TGD Inspired Theory of Consciousness: Part I. https://tgdtheory.fi/tgdhtml/Btgdconsc1.html*. Available at: https://tgdtheory.fi/pdfpool/qualia.pdf, 2023.

[K51] Pitkänen M. *Genes and Memes*. Online book. Available at: https://www.tgdtheory.fi/tgdhtml/genememe.html., 2023.

[K52] Pitkänen M. Genes and Memes. In *Genes and Memes: Part I. https://tgdtheory.fi/tgdhtml/Bgenememe1.html*. Available at: https://tgdtheory.fi/pdfpool/genememec.pdf, 2023.

[K53] Pitkänen M. Homeopathy in Many-Sheeted Space-Time. In *TGD Universe as a Conscious Hologram. https://tgdtheory.fi/tgdhtml/Bholography.html*. Available at: https://tgdtheory.fi/pdfpool/homeoc.pdf, 2023.

[K54] Pitkänen M. *Hyper-finite Factors and Dark Matter Hierarchy*. Online book. Available at: https://www.tgdtheory.fi/tgdhtml/neuplanck.html., 2023.

[K55] Pitkänen M. Identification of the WCW Kähler Function. In *Quantum Physics as Infinite-Dimensional Geometry. https://tgdtheory.fi/tgdhtml/Btgdgeom.html*. Available at: https://tgdtheory.fi/pdfpool/kahler.pdf., 2023.

[K56] Pitkänen M. Knots and TGD. In *Quantum Physics as Infinite-Dimensional Geometry. https://tgdtheory.fi/tgdhtml/Btgdgeom.html*. Available at: https://tgdtheory.fi/pdfpool/knotstgd.pdf, 2023.

[K57] Pitkänen M. Macroscopic Quantum Coherence and Quantum Metabolism as Different Sides of the Same Coin: Part I. In *TGD Universe as a Conscious Hologram. https://tgdtheory.fi/tgdhtml/Bholography.html*. Available at: https://tgdtheory.fi/pdfpool/metab.pdf, 2023.

[K58] Pitkänen M. Macroscopic Quantum Coherence and Quantum Metabolism as Different Sides of the Same Coin: Part II. In *TGD Universe as a Conscious Hologram. https://tgdtheory.fi/tgdhtml/Bholography.html*. Available at: https://tgdtheory.fi/pdfpool/molephoto.pdf, 2023.

[K59] Pitkänen M. Macroscopic Quantum Phenomena and CP_2 Geometry. In *TGD and Condensed Matter. https://tgdtheory.fi/tgdhtml/BTGDcondmat.html*. Available at: https://tgdtheory.fi/pdfpool/super.pdf, 2023.

[K60] Pitkänen M. Magnetic Sensory Canvas Hypothesis. In *TGD and Quantum Biology: Part I. https://tgdtheory.fi/tgdhtml/Bqbio1.html*. Available at: https://tgdtheory.fi/pdfpool/mec.pdf, 2023.

[K61] Pitkänen M. *Magnetospheric Consciousness*. Online book. Available at: https://www.tgdtheory.fi/tgdhtml/magnconsc.html., 2023.

[K62] Pitkänen M. Magnetospheric Sensory Representations. In *Magnetospheric Consciousness*. *https: // tgdtheory. fi/ tgdhtml/ Bmagnconsc. html* . Available at: https://tgdtheory. fi/pdfpool/srepres.pdf, 2023.

[K63] Pitkänen M. Many-Sheeted DNA. In *Genes and Memes: Part I. https: // tgdtheory. fi/ tgdhtml/ Bgenememe1. html* . Available at: https://tgdtheory.fi/pdfpool/genecodec. pdf, 2023.

[K64] Pitkänen M. Massless states and particle massivation. In *p-Adic Physics. https: // tgdtheory. fi/ tgdhtml/ Bpadphys. html* . Available at: https://tgdtheory. fi/pdfpool/mless.pdf, 2023.

[K65] Pitkänen M. *Mathematical Aspects of Consciousness Theory*. Online book. Available at: https://www.tgdtheory.fi/tgdhtml/mathconsc.html, 2023.

[K66] Pitkänen M. Matter, Mind, Quantum. In *TGD Inspired Theory of Consciousness: Part I. https: // tgdtheory. fi/ tgdhtml/ Btgdconsc1. html* . Available at: https://tgdtheory. fi/pdfpool/conscic.pdf, 2023.

[K67] Pitkänen M. Meditation, Mind-Body Medicine and Placebo: TGD point of view. In *TGD Inspired Theory of Consciousness: Part III. https: // tgdtheory. fi/ tgdhtml/ Btgdconsc3. html* . Available at: https://tgdtheory.fi/pdfpool/panel.pdf, 2023.

[K68] Pitkänen M. More about TGD Inspired Cosmology. In *Physics in Many-Sheeted Space-Time: Part II. https: // tgdtheory. fi/ tgdhtml/ Btgdclass2. html* . Available at: https://tgdtheory.fi/pdfpool/cosmomore.pdf, 2023.

[K69] Pitkänen M. More Precise TGD View about Quantum Biology and Prebiotic Evolution. In *Evolution in TGD Universe. https: // tgdtheory. fi/ tgdhtml/ Btgdevolution. html* . Available at: https://tgdtheory.fi/pdfpool/geesink.pdf, 2023.

[K70] Pitkänen M. Negentropy Maximization Principle. In *TGD Inspired Theory of Consciousness: Part I. https: // tgdtheory. fi/ tgdhtml/ Btgdconsc1. html* . Available at: https://tgdtheory.fi/pdfpool/nmpc.pdf, 2023.

[K71] Pitkänen M. New Physics Predicted by TGD: Part I. In *p-Adic Physics. https: // tgdtheory. fi/ tgdhtml/ Bpadphys. html* . Available at: https://tgdtheory. fi/pdfpool/TGDnewphys1.pdf, 2023.

[K72] Pitkänen M. New Physics Predicted by TGD: Part II. In *p-Adic Physics. https: // tgdtheory. fi/ tgdhtml/ Bpadphys. html* . Available at: https://tgdtheory. fi/pdfpool/TGDnewphys2.pdf, 2023.

[K73] Pitkänen M. Non-locality in quantum theory, in biology and neuroscience, and in remote mental interactions: TGD perspective. In *TGD Inspired Theory of Consciousness: Part III. https: // tgdtheory. fi/ tgdhtml/ Btgdconsc3. html* . Available at: https://tgdtheory. fi/pdfpool/nonlocal.pdf, 2023.

[K74] Pitkänen M. Nuclear String Hypothesis. In *TGD and Nuclear Physics. https: // tgdtheory. fi/ tgdhtml/ Bnucl. html* . Available at: https://tgdtheory.fi/pdfpool/ nuclstring.pdf, 2023.

[K75] Pitkänen M. Number theoretic vision, Hyper-finite Factors and S-matrix. In *Quantum TGD: Part I. https: // tgdtheory. fi/ tgdhtml/ Btgdquantum1. html* . Available at: https:// tgdtheory.fi/pdfpool/UandM.pdf, 2023.

[K76] Pitkänen M. *p-Adic length Scale Hypothesis*. Online book. Available at: https://www. tgdtheory.fi/tgdhtml/padphys.html., 2023.

[K77] Pitkänen M. p-Adic Particle Massivation: Hadron Masses. In *p-Adic Physics. https: // tgdtheory. fi/ tgdhtml/ Bpadphys. html* . Available at: https://tgdtheory. fi/pdfpool/mass3.pdf, 2023.

[K78] Pitkänen M. Physics as a Generalized Number Theory. In *Topological Geometrodynamics: Overview: Part I. https: // tgdtheory. fi/ tgdhtml/ Btgdview1. html* . Available at: https://tgdtheory.fi/pdfpool/tgdnumber.pdf, 2023.

[K79] Pitkänen M. Quantum Antenna Hypothesis. In *Bio-Systems as Self-Organizing Quantum Systems. https: // tgdtheory. fi/ tgdhtml/ BbioSO. html* . Available at: https://tgdtheory.fi/pdfpool/tubuc.pdf, 2023.

[K80] Pitkänen M. Quantum Arithmetics and the Relationship between Real and p-Adic Physics. In *TGD as a Generalized Number Theory: Part III. https: // tgdtheory. fi/ tgdhtml/ Btgdnumber3. html* . Available at: https://tgdtheory.fi/pdfpool/qarithmetics.pdf, 2023.

[K81] Pitkänen M. Quantum Astrophysics. In *Physics in Many-Sheeted Space-Time: Part II. https: // tgdtheory. fi/ tgdhtml/ Btgdclass2. html* . Available at: https://tgdtheory.fi/pdfpool/qastro.pdf, 2023.

[K82] Pitkänen M. Quantum Control and Coordination in Bio-Systems. In *Bio-Systems as Self-Organizing Quantum Systems. https: // tgdtheory. fi/ tgdhtml/ BbioSO. html* . Available at: https://tgdtheory.fi/pdfpool/qcococII.pdf, 2023.

[K83] Pitkänen M. Quantum gravity, dark matter, and prebiotic evolution. In *Evolution in TGD Universe. https: // tgdtheory. fi/ tgdhtml/ Btgdevolution. html* . Available at: https://tgdtheory.fi/pdfpool/hgrprebio.pdf, 2023.

[K84] Pitkänen M. Quantum Hall effect and Hierarchy of Planck Constants. In *TGD and Condensed Matter. https: // tgdtheory. fi/ tgdhtml/ BTGDcondmat. html* . Available at: https://tgdtheory.fi/pdfpool/anyontgd.pdf, 2023.

[K85] Pitkänen M. *Quantum Hardware of Living Matter*. Online book. Available at: https://www.tgdtheory.fi/tgdhtml/bioware.html., 2023.

[K86] Pitkänen M. Quantum Mind and Neuroscience. In *TGD and EEG: Part I. https: // tgdtheory. fi/ tgdhtml/ Btgdeeg1. html* . Available at: https://tgdtheory.fi/pdfpool/lianPN.pdf, 2023.

[K87] Pitkänen M. Quantum Mind in TGD Universe. In *TGD Inspired Theory of Consciousness: Part I. https: // tgdtheory. fi/ tgdhtml/ Btgdconsc1. html* . Available at: https://tgdtheory.fi/pdfpool/lianPC.pdf, 2023.

[K88] Pitkänen M. Quantum Mind, Magnetic Body, and Biological Body. In *TGD and Quantum Biology: Part I. https: // tgdtheory. fi/ tgdhtml/ Bqbio1. html* . Available at: https://tgdtheory.fi/pdfpool/lianPB.pdf, 2023.

[K89] Pitkänen M. Quantum Model for Bio-Superconductivity: I. In *TGD and Quantum Biology: Part I. https: // tgdtheory. fi/ tgdhtml/ Bqbio1. html* . Available at: https://tgdtheory.fi/pdfpool/biosupercondI.pdf, 2023.

[K90] Pitkänen M. Quantum Model for Bio-Superconductivity: II. In *TGD and Quantum Biology: Part I. https: // tgdtheory. fi/ tgdhtml/ Bqbio1. html* . Available at: https://tgdtheory.fi/pdfpool/biosupercondII.pdf, 2023.

[K91] Pitkänen M. Quantum Model for Hearing. In *TGD and EEG: Part II. https: // tgdtheory. fi/ tgdhtml/ Btgdeeg2. html* . Available at: https://tgdtheory.fi/pdfpool/hearing.pdf, 2023.

[K92] Pitkänen M. Quantum Model for Nerve Pulse. In *TGD and EEG: Part I. https: // tgdtheory. fi/ tgdhtml/ Btgdeeg1. html* . Available at: https://tgdtheory.fi/pdfpool/nervepulse.pdf, 2023.

[K93] Pitkänen M. Quantum Model for Paranormal Phenomena. In *TGD Inspired Theory of Consciousness: Part III. https: // tgdtheory. fi/ tgdhtml/ Btgdconsc3. html* . Available at: https://tgdtheory.fi/pdfpool/parac.pdf, 2023.

[K94] Pitkänen M. Quantum Model for Sensory Representations. In *TGD Inspired Theory of Consciousness: Part I. https: // tgdtheory. fi/ tgdhtml/ Btgdconsc1. html* . Available at: https://tgdtheory.fi/pdfpool/expc.pdf, 2023.

[K95] Pitkänen M. Quantum Model of EEG. In *TGD and EEG: Part I. https: // tgdtheory. fi/ tgdhtml/ Btgdeeg1. html* . Available at: https://tgdtheory.fi/pdfpool/eegII.pdf, 2023.

[K96] Pitkänen M. Quantum Model of Memory. In *TGD Inspired Theory of Consciousness: Part I. https: // tgdtheory. fi/ tgdhtml/ Btgdconsc1. html* . Available at: https://tgdtheory.fi/pdfpool/memoryc.pdf, 2023.

[K97] Pitkänen M. *Quantum TGD.* Online book. Available at: https://www.tgdtheory.fi/tgdhtml/tgdquantum.html., 2023.

[K98] Pitkänen M. Quantum Theory of Self-Organization. In *Bio-Systems as Self-Organizing Quantum Systems. https: // tgdtheory. fi/ tgdhtml/ BbioSO. html* . Available at: https://tgdtheory.fi/pdfpool/selforgac.pdf, 2023.

[K99] Pitkänen M. Recent View about Kähler Geometry and Spin Structure of WCW . In *Quantum Physics as Infinite-Dimensional Geometry. https: // tgdtheory. fi/ tgdhtml/ Btgdgeom. html* . Available at: https://tgdtheory.fi/pdfpool/wcwnew.pdf, 2023.

[K100] Pitkänen M. Riemann Hypothesis and Physics. In *TGD as a Generalized Number Theory: Part III. https: // tgdtheory. fi/ tgdhtml/ Btgdnumber3. html* . Available at: https://tgdtheory.fi/pdfpool/riema.pdf, 2023.

[K101] Pitkänen M. Self and Binding: Part I. In *TGD Inspired Theory of Consciousness: Part I. https: // tgdtheory. fi/ tgdhtml/ Btgdconsc1. html* . Available at: https://tgdtheory.fi/pdfpool/selfbindc.pdf, 2023.

[K102] Pitkänen M. Some questions related to the twistor lift of TGD. In *Quantum TGD: Part III. https: // tgdtheory. fi/ tgdhtml/ Btgdquantum3. html* . Available at: https://tgdtheory.fi/pdfpool/twistquestions.pdf, 2023.

[K103] Pitkänen M. Symmetries and Geometry of the "World of Classical Worlds". In *Quantum Physics as Infinite-Dimensional Geometry. https: // tgdtheory. fi/ tgdhtml/ Btgdgeom. html* . Available at: https://tgdtheory.fi/pdfpool/wcwsymm.pdf, 2023.

[K104] Pitkänen M. TGD and Astrophysics. In *Physics in Many-Sheeted Space-Time: Part II. https: // tgdtheory. fi/ tgdhtml/ Btgdclass2. html* . Available at: https://tgdtheory.fi/pdfpool/astro.pdf, 2023.

[K105] Pitkänen M. TGD and condensed matter physics. In *TGD and Condensed Matter. https: // tgdtheory. fi/ tgdhtml/ BTGDcondmat. html* . Available at: https://tgdtheory.fi/pdfpool/TGDcondmatshort.pdf, 2023.

[K106] Pitkänen M. *TGD and EEG.* Online book. Available at: https://www.tgdtheory.fi/tgdhtml/tgdeeg.html, 2023.

[K107] Pitkänen M. *TGD and Fringe Physics.* Online book. Available at: https://www.tgdtheory.fi/tgdhtml/freenergy.html., 2023.

[K108] Pitkänen M. TGD and Nuclear Physics. In *TGD and Nuclear Physics. https: // tgdtheory. fi/ tgdhtml/ Bnucl. html* . Available at: https://tgdtheory.fi/pdfpool/padnucl.pdf, 2023.

[K109] Pitkänen M. TGD and Potential Anomalies of GRT. In *Physics in Many-Sheeted Space-Time: Part I. https: // tgdtheory. fi/ tgdhtml/ Btgdclass1. html* . Available at: https://tgdtheory.fi/pdfpool/granomalies.pdf., 2023.

[K110] Pitkänen M. TGD Based Model for OBEs. In *TGD Inspired Theory of Consciousness: Part III. https: // tgdtheory. fi/ tgdhtml/ Btgdconsc3. html* . Available at: `https://tgdtheory.fi/pdfpool/OBE.pdf`, 2023.

[K111] Pitkänen M. TGD Based View about Classical Fields in Relation to Consciousness Theory and Quantum Biology. In *TGD and Quantum Biology: Part I. https: // tgdtheory. fi/ tgdhtml/ Bqbio1. html* . Available at: `https://tgdtheory.fi/pdfpool/maxtgdc.pdf`, 2023.

[K112] Pitkänen M. *TGD Based View About Living Matter and Remote Mental Interactions.* Online book. Available at: `https://www.tgdtheory.fi/tgdhtml/tgdlian.html`, 2023.

[K113] Pitkänen M. *TGD Inspired Theory of Consciousness.* Online book. Available at: `https://www.tgdtheory.fi/tgdhtml/tgdconsc.html.`, 2023.

[K114] Pitkänen M. The classical part of the twistor story. In *Quantum TGD: Part III. https: // tgdtheory. fi/ tgdhtml/ Btgdquantum3. html* . Available at: `https://tgdtheory.fi/pdfpool/twistorstory.pdf`, 2023.

[K115] Pitkänen M. The Geometry of the World of the Classical Worlds. In *Topological Geometrodynamics: Overview: Part I:https: // tgdtheory. fi/ tgdhtml/ Btgdview1. html* . Available at: `https://tgdtheory.fi/pdfpool/tgdgeom.pdf`, 2023.

[K116] Pitkänen M. The Notion of Wave-Genome and DNA as Topological Quantum Computer. In *Quantum - and Classical Computation in TGD Universe. https: // tgdtheory. fi/ tgdhtml/ Btgdcomp. html* . Available at: `https://tgdtheory.fi/pdfpool/gari.pdf`, 2023.

[K117] Pitkänen M. The Recent Status of Lepto-hadron Hypothesis. In *p-Adic Physics. https: // tgdtheory. fi/ tgdhtml/ Bpadphys. html* . Available at: `https://tgdtheory.fi/pdfpool/leptc.pdf`, 2023.

[K118] Pitkänen M. The Relationship Between TGD and GRT. In *Physics in Many-Sheeted Space-Time: Part I. https: // tgdtheory. fi/ tgdhtml/ Btgdclass1. html* . Available at: `https://tgdtheory.fi/pdfpool/tgdgrt.pdf.`, 2023.

[K119] Pitkänen M. Three new physics realizations of the genetic code and the role of dark matter in bio-systems. In *Genes and Memes: Part II. https: // tgdtheory. fi/ tgdhtml/ Bgenememe2. html* . Available at: `https://tgdtheory.fi/pdfpool/dnatqccodes.pdf`, 2023.

[K120] Pitkänen M. *Topological Geometrodynamics.* Luniver Press. Available at: `https://tinyurl.com/hgd585n.`, 2023.

[K121] Pitkänen M. *Topological Geometrodynamics: an Overview.* Online book.Available at: `https://www.tgdtheory.fi/tgdhtml/tgdview.html.`, 2023.

[K122] Pitkänen M. Was von Neumann Right After All? In *TGD and Hyper-finite Factors. https: // tgdtheory. fi/ tgdhtml/ BHFF. html* . Available at: `https://tgdtheory.fi/pdfpool/vNeumann.pdf`, 2023.

[K123] Pitkänen M. WCW Spinor Structure. In *Quantum Physics as Infinite-Dimensional Geometry. https: // tgdtheory. fi/ tgdhtml/ Btgdgeom. html* . Available at: `https://tgdtheory.fi/pdfpool/cspin.pdf`, 2023.

[K124] Pitkänen M. Why TGD and What TGD is? In *Topological Geometrodynamics: an Overview. https: // tgdtheory. fi/ tgdhtml/ Btgdview1. html* . Available at: `https://tgdtheory.fi/pdfpool/WhyTGD.pdf`, 2023.

[K125] Pitkänen M. Wormhole Magnetic Fields. In *Bio-Systems as Self-Organizing Quantum Systems. https: // tgdtheory. fi/ tgdhtml/ BbioSO. html* . Available at: `https://tgdtheory.fi/pdfpool/wormc.pdf`, 2023.

[K126] Pitkänen M. Zero Energy Ontology. In *Quantum TGD: Part I. https://tgdtheory.fi/ tgdhtml/Btgdquantum1.html*. Available at: https://tgdtheory.fi/pdfpool/ZEO.pdf, 2023.

[K127] Gariaev P Pitkänen M. Quantum Model for Remote Replication. In *Genes and Memes: Part I. https://tgdtheory.fi/tgdhtml/Bgenememe1.html*. Available at: https:// tgdtheory.fi/pdfpool/remotereplication.pdf, 2023.

Articles about TGD

[L1] Pitkänen M. Biosystems as macroscopic quantum systems. *J Non-Locality & Remote Mental Interactions*, 2002.

[L2] Pitkänen M. Basic Properties of CP_2 and Elementary Facts about p-Adic Numbers. Available at: `https://tgdtheory.fi/pdfpool/append.pdf`., 2006.

[L3] Pitkänen M. Further Progress in Nuclear String Hypothesis. Available at: `https://tgdtheory.fi/public_html/articles/nuclstring.pdf`., 2007.

[L4] Pitkänen M. Quantum Model for Nerve Pulse and EEG . Available at: `https://tgdtheory.fi/public_html/articles/pulseeg.pdf`., 2008.

[L5] Pitkänen M. TGD Inspired Quantum Model of Living Matter. Available at: `https://tgdtheory.fi/quantumbio.pdf`., 2008.

[L6] Pitkänen M. DNA Waves and Water. Available at: `https://tgdtheory.fi/public_html/articles/mont.pdf`., 2011.

[L7] Pitkänen M. DNA Waves and Water. Available at: `https://tgdtheory.fi/public_html/articles/mont.pdf`., 2011.

[L8] Pitkänen M. Generalization of thermodynamics allowing negentropic entanglement and a model for conscious information processing. Available at: `https://tgdtheory.fi/public_html/articles/thermolife.pdf`., 2011.

[L9] Pitkänen M. Sheldrake's Morphic Fields and TGD View about Quantum Biology. Available at: `https://tgdtheory.fi/public_html/articles/sheldrake.pdf`., 2011.

[L10] Pitkänen M. DNA and Water Memory: Comments on Montagnier Group's Recent Findings. *DNA Decipher Journal*, 1(1), 2011. See also `https://tgtheory.fi/public_html/articles/mont.pdf`.

[L11] Pitkänen M. How to build a quantum computer from magnetic flux tubes? Available at: `https://tgdtheory.fi/public_html/articles/fluxtubecomputer.pdf`., 2012.

[L12] Pitkänen M. Quantum Model for the Direct Currents of Becker. Available at: `https://tgdtheory.fi/public_html/articles/DCbio.pdf`., 2012.

[L13] Pitkänen M. A Vision about Quantum Jump as a Universal Cognitive Proces. Available at: `https://tgdtheory.fi/public_html/articles/hawkins.pdf`., 2013.

[L14] Pitkänen M. About Concrete Realization of Remote Metabolism. Available at: `https://tgdtheory.fi/public_html/articles/teslaling.pdf`., 2013.

[L15] Pitkänen M. Comparison of TGD inspired theory of consciousness with some other theories of consciousness, 2013.

[L16] Pitkänen M. Evolution in Many-Sheeted Space-Time: Big Vision. *DNA Decipher Journal*, 3(2), 2013. See also `https://tgtheory.fi/pdfpool/prebio.pdf`.

[L17] Pitkänen M. Evolution in Many-Sheeted Space-Time: Genetic Code. *DNA Decipher Journal*, 3(2), 2013. See also `https://tgtheory.fi/pdfpool/prebio.pdf`.

[L18] Pitkänen M. CMAP representations about TGD, and TGD inspired theory of consciousness and quantum biology. Available at: `https://www.tgdtheory.fi/tgdglossary.pdf`., 2014.

[L19] Pitkänen M. Geometric theory of harmony. Available at: `https://tgdtheory.fi/public_html/articles/harmonytheory.pdf`., 2014.

[L20] Pitkänen M. More Precise View about Remote Replication. Available at: `https://tgdtheory.fi/public_html/articles/dnabobs.pdf`., 2014.

[L21] Pitkänen M. Morphogenesis, morphostasis, and learning in TGD framework. Available at: `https://tgdtheory.fi/public_html/articles/morpho.pdf`., 2014.

[L22] Pitkänen M. New results about microtubules as quantum systems. Available at: `https://tgdtheory.fi/public_html/articles/microtubule.pdf`., 2014.

[L23] Pitkänen M. Pollack's Findings about Fourth phase of Water : TGD View. Available at: `https://tgdtheory.fi/public_html/articles/PollackYoutube.pdf`., 2014.

[L24] Pitkänen M. Music, Biology and Natural Geometry (Part I). *DNA Decipher Journal*, 4(2), 2014. See also `https://tgtheory.fi/public_html/articles/harmonytheory.pdf`.

[L25] Pitkänen M. Music, Biology and Natural Geometry (Part II). *DNA Decipher Journal*, 4(2), 2014. See also `https://tgtheory.fi/public_html/articles/harmonytheory.pdf`.

[L26] Pitkänen M. Jeremy England's vision about life and evolution: comparison with TGD approach . Available at: `https://tgdtheory.fi/public_html/articles/englandtgd.pdf`., 2015.

[L27] Pitkänen M. Cold Fusion Again . Available at: `https://tgdtheory.fi/public_html/articles/cfagain.pdf`., 2015.

[L28] Pitkänen M. Does the Physics of SmB6 Make the Fundamental Dynamics of TGD Directly Visible? 2015.

[L29] Pitkänen M. Maintenance problem for Earth's magnetic field. Available at: `https://tgdtheory.fi/public_html/articles/Bmaintenance.pdf`., 2015.

[L30] Pitkänen M. Quantitative model of high T_c super-conductivity and bio-super-conductivity. Available at: `https://tgdtheory.fi/public_html/articles/newsupercond.pdf`., 2015.

[L31] Pitkänen M. TGD based model for anesthetic action. Available at: `https://tgdtheory.fi/public_html/articles/anesthetes.pdf`., 2015.

[L32] Pitkänen M. About high Tc superconductivity and other exotic conductivities . Available at: `https://tgdtheory.fi/public_html/articles/conductors.pdf`., 2016.

[L33] Pitkänen M. About minimal surface extremals of Kähler action. Available at: `https://tgdtheory.fi/public_html/articles/minimalkahler.pdf`., 2016.

[L34] Pitkänen M. About Physical Representations of Genetic Code in Terms of Dark Nuclear Strings. Available at: `https://tgdtheory.fi/public_html/articles/genecodemodels.pdf`., 2016.

[L35] Pitkänen M. Bio-catalysis, morphogenesis by generalized Chladni mechanism, and bio-harmonies. Available at: `https://tgdtheory.fi/public_html/articles/chladnicata.pdf`., 2016.

[L36] Pitkänen M. Can quantum biology really do without new physics? Available at: `https://tgdtheory.fi/public_html/articles/RPMTGD.pdf`., 2016.

[L37] Pitkänen M. Comments about the representations in SSE-2016 conference about consciousness, biology, and paranormal phenomena. Available at: `https://tgdtheory.fi/public_html/articles/SSE.pdf`., 2016.

[L38] Pitkänen M. Holography and Quantum Error Correcting Codes: TGD View. Available at: `https://tgdtheory.fi/public_html/articles/tensornet.pdf`., 2016.

[L39] Pitkänen M. Hydrinos again. Available at: `https://tgdtheory.fi/public_html/articles/Millsagain.pdf`., 2016.

[L40] Pitkänen M. What could be the physical origin of Pythagorean scale? Available at: `https://tgdtheory.fi/public_html/articles/geesinkscale.pdf`., 2016.

[L41] Pitkänen M. What's new in TGD inspired view about phase transitions? . Available at: `https://tgdtheory.fi/public_html/articles/phasetransitions.pdf`., 2016.

[L42] Pitkänen M. Artificial Intelligence, Natural Intelligence, and TGD. Available at: `https://tgdtheory.fi/public_html/articles/AITGD.pdf`., 2017.

[L43] Pitkänen M. Cold fusion, low energy nuclear reactions, or dark nuclear synthesis? Available at: `https://tgdtheory.fi/public_html/articles/krivit.pdf`., 2017.

[L44] Pitkänen M. DMT, pineal gland, and the new view about sensory perception. Available at: `https://tgdtheory.fi/public_html/articles/dmtpineal.pdf`., 2017.

[L45] Pitkänen M. Does $M^8 - H$ duality reduce classical TGD to octonionic algebraic geometry? Available at: `https://tgdtheory.fi/public_html/articles/ratpoints.pdf`., 2017.

[L46] Pitkänen M. Does valence bond theory relate to the hierarchy of Planck constants? Available at: `https://tgdtheory.fi/public_html/articles/valenceheff.pdf`., 2017.

[L47] Pitkänen M. Life-like properties observed in a very simple system. Available at: `https://tgdtheory.fi/public_html/articles/plasticballs.pdf`., 2017.

[L48] Pitkänen M. Mysteriously disappearing valence electrons of rare Earth metals and hierarchy of Planck constants. Available at: `https://tgdtheory.fi/public_html/articles/rareearth.pdf`., 2017.

[L49] Pitkänen M. p-Adicization and adelic physics. Available at: `https://tgdtheory.fi/public_html/articles/adelicphysics.pdf`., 2017.

[L50] Pitkänen M. Philosophy of Adelic Physics. In *Trends and Mathematical Methods in Interdisciplinary Mathematical Sciences*, pages 241–319. Springer.Available at: `https://link.springer.com/chapter/10.1007/978-3-319-55612-3_11`, 2017.

[L51] Pitkänen M. Philosophy of Adelic Physics. Available at: `https://tgdtheory.fi/public_html/articles/adelephysics.pdf`., 2017.

[L52] Pitkänen M. Questions about twistor lift of TGD. Available at: `https://tgdtheory.fi/public_html/articles/twistquestions.pdf`., 2017.

[L53] Pitkänen M. Re-examination of the basic notions of TGD inspired theory of consciousness. Available at: `https://tgdtheory.fi/public_html/articles/conscrit.pdf`., 2017.

[L54] Pitkänen M. About dark variants of DNA, RNA, and amino-acids. Available at: `https://tgdtheory.fi/public_html/articles/darkvariants.pdf`., 2018.

[L55] Pitkänen M. About the Correspondence of Dark Nuclear Genetic Code and Ordinary Genetic Code. Available at: `https://tgdtheory.fi/public_html/articles/codedarkcode.pdf`., 2018.

[L56] Pitkänen M. About the physical interpretation of the velocity parameter in the formula for the gravitational Planck constant . Available at: `https://tgdtheory.fi/public_html/articles/vzero.pdf`., 2018.

[L57] Pitkänen M. Could also RNA and protein methylation of RNA be involved with the expression of molecular emotions? Available at: `https://tgdtheory.fi/public_html/articles/synapticmoods.pdf`., 2018.

[L58] Pitkänen M. Could cancer be a disease of magnetic body? Available at: `https://tgdtheory.fi/public_html/articles/nanotesla.pdf.`, 2018.

[L59] Pitkänen M. Dark valence electrons and color vision. Available at: `https://tgdtheory.fi/public_html/articles/colorvision.pdf.`, 2018.

[L60] Pitkänen M. Did RNA Replicate in Codon-Wise Manner during RNA Era? Available at: `hhttps://tgtheory.fi/public_html/articles/RNAreplication.pdf.`, 2018.

[L61] Pitkänen M. Emotions as sensory percepts about the state of magnetic body? Available at: `https://tgdtheory.fi/public_html/articles/emotions.pdf.`, 2018.

[L62] Pitkänen M. Expanding Earth Model and Pre-Cambrian Evolution of Continents, Climate, and Life. Available at: `https://tgdtheory.fi/public_html/articles/expearth.pdf.`, 2018.

[L63] Pitkänen M. Five new strange effects associated with galaxies. Available at: `https://tgdtheory.fi/public_html/articles/3galeffects.pdf.`, 2018.

[L64] Pitkänen M. Getting philosophical: some comments about the problems of physics, neuroscience, and biology. Available at: `https://tgdtheory.fi/public_html/articles/philosophic.pdf.`, 2018.

[L65] Pitkänen M. Homonymy of the genetic code from TGD point of view. Available at: `https://tgdtheory.fi/public_html/articles/homonymy.pdf.`, 2018.

[L66] Pitkänen M. Maxwell's lever rule and expansion of water in freezing: two poorly understood phenomena. Available at: `https://tgdtheory.fi/public_html/articles/leverule.pdf.`, 2018.

[L67] Pitkänen M. Morphogenesis in TGD Universe. Available at: `https://tgdtheory.fi/public_html/articles/morphoTGD.pdf.`, 2018.

[L68] Pitkänen M. New insights about quantum criticality for twistor lift inspired by analogy with ordinary criticality. Available at: `https://tgdtheory.fi/public_html/articles/zeocriticality.pdf.`, 2018.

[L69] Pitkänen M. New results in the model of bio-harmony. Available at: `https://tgdtheory.fi/public_html/articles/harmonynew.pdf.`, 2018.

[L70] Pitkänen M. Sensory perception and motor action as time reversals of each other: a royal road to the understanding of other minds? Available at: `https://tgdtheory.fi/public_html/articles/timemirror.pdf.`, 2018.

[L71] Pitkänen M. TGD view about coupling constant evolution. Available at: `https://tgdtheory.fi/public_html/articles/ccevolution.pdf.`, 2018.

[L72] Pitkänen M. TGD view about quasars. Available at: `https://tgdtheory.fi/public_html/articles/meco.pdf.`, 2018.

[L73] Pitkänen M. The Recent View about Twistorialization in TGD Framework. Available at: `https://tgdtheory.fi/public_html/articles/smatrix.pdf.`, 2018.

[L74] Pitkänen M. On the Correspondence of Dark Nuclear Genetic Code & Ordinary Genetic Code. *DNA Decipher Journal*, 8(1), 2018. See also `https://tgtheory.fi/public_html/articles/codedarkcode.pdf.`

[L75] Pitkänen M. An overall view about models of genetic code and bio-harmony. Available at: `https://tgdtheory.fi/public_html/articles/gcharm.pdf.`, 2019.

[L76] Pitkänen M. Are fundamental entities discrete or continous and what discretization at fundamental level could mean? Available at: `https://tgdtheory.fi/public_html/articles/zetaspecu.pdf.`, 2019.

[L77] Pitkänen M. Copenhagen interpretation dead: long live ZEO based quantum measurement theory! Available at: `https://tgdtheory.fi/public_html/articles/Bohrdead.pdf.`, 2019.

[L78] Pitkänen M. Cosmic string model for the formation of galaxies and stars. Available at: `https://tgdtheory.fi/public_html/articles/galaxystars.pdf.`, 2019.

[L79] Pitkänen M. Cosmology in crisis. Available at: `https://tgdtheory.fi/public_html/articles/cosmocrisis.pdf.`, 2019.

[L80] Pitkänen M. Could Mars have intra-planetary life? Available at: `https://tgdtheory.fi/public_html/articles/Mars.pdf.`, 2019.

[L81] Pitkänen M. Earhquakes and volcanic eruptions as macroscopic quantum jumps in zero energy ontology. Available at: `https://tgdtheory.fi/public_html/articles/earthquakes.pdf.`, 2019.

[L82] Pitkänen M. Epigenesis, inherited memories and moods lasting over several generations. Available at: `https://tgdtheory.fi/public_html/articles/amoebamemory.pdf.`, 2019.

[L83] Pitkänen M. $M^8 - H$ duality and consciousness. Available at: `https://tgdtheory.fi/public_html/articles/M8Hconsc.pdf.`, 2019.

[L84] Pitkänen M. Minimization of Gibbs free energy as thermodynamical variational principle in TGD framework. Available at: `https://tgdtheory.fi/public_html/articles/hydrophoby.pdf.`, 2019.

[L85] Pitkänen M. Multilocal viruses. Available at: `https://tgdtheory.fi/public_html/articles/viralstrange.pdf.`, 2019.

[L86] Pitkänen M. New results related to $M^8 - H$ duality. Available at: `https://tgdtheory.fi/public_html/articles/M8Hduality.pdf.`, 2019.

[L87] Pitkänen M. Quantum self-organization by h_{eff} changing phase transitions. Available at: `https://tgdtheory.fi/public_html/articles/heffselforg.pdf.`, 2019.

[L88] Pitkänen M. Scattering amplitudes and orbits of cognitive representations under subgroup of symplectic group respecting the extension of rationals . Available at: `https://tgdtheory.fi/public_html/articles/symplorbsm.pdf.`, 2019.

[L89] Pitkänen M. Solar Metallicity Problem from TGD Perspective. Available at: `https://tgdtheory.fi/public_html/articles/darkcore.pdf.`, 2019.

[L90] Pitkänen M. Solar Surprise. Available at: `https://tgdtheory.fi/public_html/articles/solarsycle.pdf.`, 2019.

[L91] Pitkänen M. Some applications of TGD inspired quantum biology: bio-chemistry, metabolism, replication. Available at: `https://tgdtheory.fi/public_html/articles/bioexamples.pdf.`, 2019.

[L92] Pitkänen M. Some comments related to Zero Energy Ontology (ZEO). Available at: `https://tgdtheory.fi/public_html/articles/zeoquestions.pdf.`, 2019.

[L93] Pitkänen M. Tesla still inspires. Available at: `https://tgdtheory.fi/public_html/articles/teslastill.pdf.`, 2019.

[L94] Pitkänen M. Waterbridge experiment from TGD point of view. Available at: `https://tgdtheory.fi/public_html/articles/waterbridge.pdf.`, 2019.

[L95] Pitkänen M. An Overall View about Models of Genetic Code & Bio-harmony. *DNA Decipher Journal*, 9(2), 2019. See also `https://tgtheory.fi/public_html/articles/gcharm.pdf.`

[L96] Pitkänen M. A critical re-examination of $M^8 - H$ duality hypothesis: part I. Available at: `https://tgdtheory.fi/public_html/articles/M8H1.pdf.`, 2020.

[L97] Pitkänen M. A critical re-examination of $M^8 - H$ duality hypothesis: part II. Available at: `https://tgdtheory.fi/public_html/articles/M8H2.pdf.`, 2020.

[L98] Pitkänen M. A model of protocell based on Pollack effect. Available at: `https://tgdtheory.fi/public_html/articles/pollackoparin.pdf.`, 2020.

[L99] Pitkänen M. Could brain be represented as a hyperbolic geometry? Available at: `https://tgdtheory.fi/public_html/articles/hyperbolicbrain.pdf.`, 2020.

[L100] Pitkänen M. Could quantum randomness have something to do with classical chaos? Available at: `https://tgdtheory.fi/public_html/articles/chaostgd.pdf.`, 2020.

[L101] Pitkänen M. How to compose beautiful music of light in bio-harmony? `https://tgdtheory.fi/public_html/articles/bioharmony2020.pdf.`, 2020.

[L102] Pitkänen M. New results about dark DNA inspired by the model for remote DNA replication. Available at: `https://tgdtheory.fi/public_html/articles/darkdnanew.pdf.`, 2020.

[L103] Pitkänen M. The dynamics of SSFRs as quantum measurement cascades in the group algebra of Galois group. Available at: `https://tgdtheory.fi/public_html/articles/SSFRGalois.pdf.`, 2020.

[L104] Pitkänen M. Results about Dark DNA & Remote DNA Replication. *DNA Decipher Journal*, 10(1), 2020. See also `https://tgtheory.fi/public_html/articles/darkdnanew.pdf.`

[L105] Pitkänen M. The Dynamics of State Function Reductions as Quantum Measurement Cascades. *Pre-Space-Time Journal*, 11(2), 2020. See also `https://tgtheory.fi/public_html/articles/SSFRGalois.pdf.`

[L106] Pitkänen M. About the role of Galois groups in TGD framework. `https://tgdtheory.fi/public_html/articles/GaloisTGD.pdf.`, 2021.

[L107] Pitkänen M. EEG and the structure of magnetosphere. `https://tgdtheory.fi/public_html/articles/mseeg.pdf.`, 2021.

[L108] Pitkänen M. Is genetic code part of fundamental physics in TGD framework? Available at: `https://tgdtheory.fi/public_html/articles/TIH.pdf.`, 2021.

[L109] Pitkänen M. Revolution in chemistry. `https://tgdtheory.fi/public_html/articles/newchemistry.pdf.`, 2021.

[L110] Pitkänen M. Some questions concerning zero energy ontology. `https://tgdtheory.fi/public_html/articles/zeonew.pdf.`, 2021.

[L111] Pitkänen M. TGD as it is towards the end of 2021. `https://tgdtheory.fi/public_html/articles/TGD2021.pdf.`, 2021.

[L112] Pitkänen M. Time reversal and the anomalies of rotating magnetic systems. Available at: `https://tgdtheory.fi/public_html/articles/freereverse.pdf.`, 2021.

[L113] Pitkänen M. What could 2-D minimal surfaces teach about TGD? `https://tgdtheory.fi/public_html/articles/minimal.pdf.`, 2021.

[L114] Pitkänen M. About TGD counterparts of twistor amplitudes: part I. `https://tgdtheory.fi/public_html/articles/twisttgd1.pdf.`, 2022.

[L115] Pitkänen M. About TGD counterparts of twistor amplitudes: part II. `https://tgdtheory.fi/public_html/articles/twisttgd2.pdf.`, 2022.

[L116] Pitkänen M. Comparison of Orch-OR hypothesis with the TGD point of view. `https://tgdtheory.fi/public_html/articles/penrose.pdf.`, 2022.

[L117] Pitkänen M. Finite Fields and TGD. `https://tgdtheory.fi/public_html/articles/finitefieldsTGD.pdf.`, 2022.

[L118] Pitkänen M. Hen and egg problems of biology from TGD point of view. `https://tgdtheory.fi/public_html/articles/henegg.pdf.`, 2022.

[L119] Pitkänen M. How animals without brain can behave as if they had brain. `https://tgdtheory.fi/public_html/articles/precns.pdf.`, 2022.

[L120] Pitkänen M. Intersection form for 4-manifolds, knots and 2-knots, smooth exotics, and TGD. `https://tgdtheory.fi/public_html/articles/finitefieldsTGD.pdf.`, 2022.

[L121] Pitkänen M. Some New Ideas Related to Langlands Program *viz.* TGD. `https://tgdtheory.fi/public_html/articles/Langlands2022.pdf.`, 2022.

[L122] Pitkänen M. TGD view about water memory and the notion of morphogenetic field . `https://tgdtheory.fi/public_html/articles/watermorpho.pdf.`, 2022.

[L123] Pitkänen M. The realization of genetic code in terms of dark nucleon and dark photon triplets. `https://tgdtheory.fi/public_html/articles/darkcode.pdf.`, 2022.

[L124] Pitkänen M. Trying to fuse the basic mathematical ideas of quantum TGD to a single coherent whole. `https://tgdtheory.fi/public_html/articles/fusionTGD.pdf.`, 2022.

[L125] Pitkänen M. Two objections against p-adic thermodynamics and their resolution. `https://tgdtheory.fi/public_html/articles/padmass2022.pdf.`, 2022.

[L126] Pitkänen M. About tessellations in hyperbolic 3-space and their relation to the genetic code . `https://tgdtheory.fi/public_html/articles/tessellationH3.pdf.`, 2023.

[L127] Pitkänen M. About long range electromagnetic quantum coherence in TGD Universe. `https://tgdtheory.fi/public_html/articles/hem.pdf.`, 2023.

[L128] Pitkänen M. About the mechanism of the energy transfer in photosynthesis. `https://tgdtheory.fi/public_html/articles/photosynth.pdf.`, 2023.

[L129] Pitkänen M. Are Conscious Computers Possible in TGD Universe? `https://tgdtheory.fi/public_html/articles/tgdcomp.pdf.`, 2023.

[L130] Pitkänen M. Could neuronal system and even GPT give rise to a computer with a variable arrow of time? `https://tgdtheory.fi/public_html/articles/GPT.pdf.`, 2023.

[L131] Pitkänen M. Holography and Hamilton-Jacobi Structure as 4-D generalization of 2-D complex structure. `https://tgdtheory.fi/public_html/articles/HJ.pdf.`, 2023.

[L132] Pitkänen M. Is Negentropy Maximization Principle needed as an independent principle? `https://tgdtheory.fi/public_html/articles/NMPcrit.pdf.`, 2023.

[L133] Pitkänen M. New result about causal diamonds from the TGD view point of view. `https://tgdtheory.fi/public_html/articles/CDconformal.pdf.`, 2023.

[L134] Pitkänen M. Pollack effect, lightnings and ball lightnings. `https://tgdtheory.fi/public_html/articles/balllightning.pdf.`, 2023.

[L135] Pitkänen M. Reduction of standard model structure to CP_2 geometry and other key ideas of TGD. `https://tgdtheory.fi/public_html/articles/cp2etc.pdf.`, 2023.

[L136] Pitkänen M. Symmetries and Geometry of the "World of Classical Worlds" . `https://tgdtheory.fi/public_html/articles/wcwsymm.pdf.`, 2023.

[L137] Pitkänen M. TGD view of Michael Levin's work. `https://tgdtheory.fi/public_html/articles/Levin.pdf.`, 2023.

[L138] Pitkänen M. A fresh look at $M^8 - H$ duality and Poincare invariance. `https://tgdtheory.fi/public_html/articles/TGDcritics.pdf.`, 2024.

[L139] Pitkänen M. About the Recent TGD Based View Concerning Cosmology and Astrophysics. `https://tgdtheory.fi/public_html/articles/3pieces.pdf`., 2024.

[L140] Pitkänen M. Modified Dirac equation and the holography=holomorphy hypothesis. `https://tgdtheory.fi/public_html/articles/modDir.pdf`., 2024.

[L141] Pitkänen M. What gravitons are and could one detect them in TGD Universe? `https://tgdtheory.fi/public_html/articles/whatgravitons.pdf`., 2024.

[L142] Pitkänen M and Rastmanesh R. Homeostasis as self-organized quantum criticality. Available at: `https://tgdtheory.fi/public_html/articles/SP.pdf`., 2020.

[L143] Pitkänen M and Rastmanesh R. New Physics View about Language: part I. Available at: `https://tgdtheory.fi/public_html/articles/languageTGD1.pdf`., 2020.

[L144] Pitkänen M and Rastmanesh R. New Physics View about Language: part II. Available at: `https://tgdtheory.fi/public_html/articles/languageTGD2.pdf`., 2020.

[L145] Pitkänen M and Rastmanesh R. The based view about dark matter at the level of molecular biology. Available at: `https://tgdtheory.fi/public_html/articles/darkchemi.pdf`., 2020.

Chapter 13

A Model for Protein Folding and Bio-catalysis

13.1 Introduction

The model for the evolution of the genetic code leads [**?**] to the idea that the folding of proteins obeys a code inherited from the genetic code. One can imagine several variants of this code. One of them is that amino-acid behaves like the conjugate Y_c of the middle nucleotide of the codon XYZ coding for it. Conjugation for amino-acids would correspond to the hydrophilic-hydrophobic dichotomy. Also catalyst action could reduce to effective base pairing in this picture chemically and at the level of quarks associated with the flux tube to matter antimatter conjugation. The guess that amino-acid and its conjugate form pairs turned out to be wrong however and after various twists and turns I ended up with the hypothesis that the amino-acid in protein behaves like $Y_c Z_c$ where Z corresponds to third nucleotide for some codon coding for the amino-acid.

There exists a wonderful book "Proteins: Structures and Molecular Properties" by Thomas E. Creighton published 1993 [I142] and I am grateful for Timo Immonen for possibility to use the book. In the following I freely refer to the general facts discussed in this book rather than referring separately to every detail.

13.1.1 Flux Tubes As Correlates Of Directed Attention At Molecular Level

After some trials one ends up with a general conceptualization of the situation with the identification of ("wormhole") magnetic flux tubes as correlates for attention at molecular level so that a direct connection with TGD inspired theory of consciousness emerges at quantitative level. Whether wormhole flux tubes or ordinary flux tubes are needed is not a completely settled question yet and the attribute "wormhole" will not be used in the sequel. This suggests a generalization of the DNA as topological quantum computer paradigm making it much more detailed.

There are too many uncertainties involved to allow anything except playing with the options that one is able to imagine. There are two kinds of flux tubes. Those between amino-acids and those between amino-acids and water molecules. The contractions of flux tubes in $\hbar$ changing phase transitions are expected to be important for protein folding and could also give rise to the interaction responsible for hydrophily and hydrophoby and be therefore highly relevant for protein folding. A basic question about which I became aware only about one year after working out the first draft of this chapter concerns the relative importance of these two kinds of flux tubes. The first model assumed that only amino-acid-amino-acid flux tubes are relevant and assumed strong selection rules inspired by DNA as TQC model. The second model which emerged year later represents an extreme in which only the flux tube connections between amino-acids and water molecules assumed to be responsible for hydrophily and hydrophoby induce the interactions between amino-acids as secondary interactions. This model works surprisingly well at qualitative level.

13.1.2 The Model Of Folding Code Based On Flux Tube Connections Between Amino-Acids

The first model assumes that only the flux tubes between amino-acids are relevant for protein folding.

What kind of atoms can be connected by flux tubes?

1. Hydrogen bonds play a key role in bio-catalysis but are not understood completely satisfactorily in the standard chemistry. Hence the basic question is whether hydrogen bonds can be regarded as or are accompanied by short (wormhole) magnetic flux tubes: note that the subject-object asymmetry of directed attention would correspond to donor-acceptor asymmetry of they hydrogen bond. If this is the case, the identification of the magnetic flux tube connection as a prerequisite for a hydrogen bond or as hydrogen bond becomes natural. At least the atoms able to form hydrogen bonds could form flux tube contacts so that the model would be very predictive and would conform with the known important role of hydrogen bonds in bio-catalysis.

2. The fact that hydrogen bonds connect base pairs suggests a generalization of the notion of base pairing stating that under some conditions amino-acids coded by XYZ and UY_cV can behave like base pairs. These amino-acic pairs correspond to pairs of amino-acid residues which are hydrophilic *resp.* hydrophobic and hydrophobic residue do not form hydrogen bonds in general. These flux tubes would thus be more general and in general long. The model for DNA as topological quantum computer requires this kind of flux tubes and they would in general connect atoms or molecules which act as acceptors in hydrogen bonding: $O =$ atom in amino-acid and aromatic ring are basic examples.

3. If one assumes that both $N - H$ and $O =$ associated with the constant part of the amino-acid can act as flux tube terminals and represent Z and Y nucleotides of the codon XYZ coding for the amino-acid, one obtains $Y = Z$ pairing of $O = -O =$ flux tubes are allowed and $Y = Z_c$ pairing if only hydrogen bond like pairings are allowed.

Color inheritance by a reconnection of flux tubes

1. There should exist some mechanism allowing amino-acids to inherit the base pairing property from the tRNAs associated with them so that one can identify amino-acid with the middle nucleotide of the codon coding it. If tRNA middle nucleotide is connected to $O =$ of the amino-acid, this becomes possible since the reconnection of flux tubes preserves the "color" of the flux tubes coded by (A,T,G,C) that is by the quark or anti-quark coding for the nucleotide. The temporary formation of a hydrogen bond between $N - H$ and $O =$ of two amino-acids as in the case of alpha helix would allow $N - H$ to inherit the conjugate of the color associated with $O =$. Alternative interpretation is that this hydrogen bond is possible only if the predetermined color of $N - H$ is consistent with the inherited one. The inheritance of flux tube color would be a completely general mechanism and even the donor atoms in the residues of amino-acids could inherit the color of $O =$ in this way.

2. A possible interpretation for the fixing of the flux tube color is in terms of quantum measurement selecting one color from quantum superposition in the reconnection process. This would mean that the unitary process can bring superposition back and reconnection process can change the inherited color. The hydrogen bonds between water molecules could correspond to quantum superpositions of different colors. This superposition property might relate to the wobble base pairing phenomenon for the third nucleotide in tRNA.

Folding code

The identification of $N - H$ as a representation for the conjugate of the third nucleotide Z means that amino-acids would remember which codon coded them. If only hydrogen bond like flux tubes are allowed, flux tubes can connect only amino-acids satisfying $Y = Z_c$. If $= O - O =$ flux tubes are allowed $Y = Z$ rule favored by the model of DNA as topological quantum computer

follows. The isospin symmetry of the third nucleotide implies that both rules are quite flexible. If one identifies hydrogen bond with flux tube ($Y(n) = Z(n + k)$) the model works badly for both options. If one assumes only that the presence of a flux tube connecting amino-acids in either direction ($Y(n) = Z(n + k)$ or $Z(n) = Y(n + k)$) is a prerequisite for the formation of hydrogen bond, the model works. $Y = Z$ rule is favored by the study of five enzymes: the possible average length of alpha helix is considerably longer than the average length of alpha helix if gene is the unique gene allowing to satisfy $Y = Z$ rule. The explicit study of alpha helices and beta sheets for these enzymes demonstrates that the failure to satisfy the condition for the existence of hydrogen bond fails rarely and at most for two amino-acids (for 2 amino-acids in single case only).

$Y = Z$ rule could mean a solution of the basic problem of proteonics: Do genes determine the folding of proteins and how this would take place? The interpretation would be that the information loss suggested by the many-to-one character of the genetic code is only apparent. The apparently lost information which corresponds to the $A - G$ and $T - C$ symmetries of the third nucleotide codes for the hydrogen bonding and hence for the folding of the protein. The model in its most stringent form is easy to kill since in the case of alpha helices and beta sheets the hydrogen bonding fixes completely the DNA sequence coding for the protein. A weaker variant of the model based on quantum variant of wobble base pairing: in this case there are no conditions on DNA sequence. It turns out that only this variant works. Hence hydrogen bonded amino-acid behave as if they were coded by the unique codon consistent with $Y = Z$ rule.

Quantitative model

The quantitative model relies on the assumption that the contribution of a flux tube connecting two amino-acids to the potential energy depends only on the distance between the molecules in question. The extremals of the total interaction energy are same for any choice of the potential and only the absolute minimum of the interaction energy depends on the choice of the potential. The simplest potential corresponds to harmonic oscillator potential and would explain formation of alpha helices and beta sheets and with the fact that hydrophilic and hydrophobic residues tend to have a large distance and only few flux tube contacts. For large Planck constant also long flux tubes could correspond to attractive harmonic oscillator potential. Also the contribution of other interactions between neighboring amino-acids are expected to be present but are neglected in the simplest model. The model predicts alpha helices and beta sheets, and more generally, periodic structures, as solutions to energy minimization equations.

13.1.3   A Model For Protein Folding Based On Flux Tubes Between Amino-Acids And Water Molecules

This proposal represents a diametrical opposite of the first model in the sense in that it assumes flux tube connections only between amino-acids and water molecules. These flux tubes mediate an attractive (repulsive) interaction in the case of hydrophily (hydrophoby) due to the behavior of magnetic (presumably) interaction energy as a function of Planck constant (or integers characterizing the level of dark matter) assignable to the flux tube. For hydrophoby (hydrophily) the interaction energy is minimized for long (short) flux tubes. The interaction between amino-acids is induced by this interaction in a way analogous to how the interaction between electrons and ions induces secondary interaction between the members of a Cooper pair. The model explains the basic qualitative aspects of protein folding and the quantitative model of folding based on amino-acid-amino-acid flux tubes allows a generalization which is however discussed at numerical level.

13.1.4   Protein folding, hydrophoby and hydrophily, and molecular attention

The third proposal asks whether protein folding could be induced by the flux tube connections of protein with water's MB rather than between proteins as in the first two models. This model is certainly an idealization since S-S valence bonds are known to play an important part in the folding. These flux tube connections could be accompanied by hydrogen bonds - even longer than usual if h_{eff} as spectrum for water as has been proposed. This involves more detailed ideas

about the origin of hydrophobia and hydrophilia at the level of magnetic body (MB) discussed more quantitatively in [L84]. Hydrophilic amino acids would tend to form flux tube connections with the MB of water unlike hydrophobic amino acids. The formation of flux tube connection would serve as a correlate for attention at molecular level.

13.1.5 Postlude

The above summarized efforts are just the first attempts to apply TGD views in order to understand protein folding, and must be taken just as excercises without deeper vision about the meanings of protein folding and folding code assuming it exists.

Decade after writing this chapter the vision about the role of DNA in TGD Universe evolved with inspiration coming from the model of water memory and homeopathy and the realization that homeopathy might represent a core elemement in the functioning of immune system involving new physics in an essential way. The key idea is that dark variants of amino-acid sequences would have coded for the 2-braiding of the magnetic flux tube patterns defining invader molecule as a dynamical process: dark proteins would mimic physically the braiding of invader molecule's magnetic body. Dark DNA sequences would have coded this braiding symbolically and their translation to dark amino-acids would transform symbolic representation to a concrete physical one. The emergence of ordinary DNA and amino-acids would have realized the same at biochemical level and amino-acid sequences representing the invader would serve as antigene attaching to the invader molecule. Not only the pattern produced in protein folding but also the temporal pattern of protein folding would be coded by DNA.

It would be fascinating if the vision about the role of flux tube connections would generalize to interactions of all molecules in living matter. The mere selection rules would mean hidden simplicity behind extremely complex looking interactions in living matter. The model for protein folding and catalytic action described in the original version of this chapter was the first attempt in this direction. At the end of the chapter an improvement of the model inspired by recent considerations is suggested.

Several persons have helped me in writing this chapter. I want to express my gratitude to Ulla Mattfolk for informing about the idea of protein folding code and to Dale Trenary for interesting discussions, for suggesting proteins which could allow to test the model, and for providing concrete help in loading data help from protein data bank. Also I want to thank Timo Immonen for discussions and for loaning the excellent book "Proteins: Structures and Molecular Properties" of Creighton. I am also grateful for Pekka Rapinoja for writing the program transforming protein data file to a form readable by MATLAB.

The appendix of the book gives a summary about basic concepts of TGD with illustrations. Pdf representation of same files serving as a kind of glossary can be found at `http://tgdtheory.fi/tgdglossary.pdf` [L18].

13.2 A Model For Flux Tubes

Biochemistry represents extremely complex and refined choreography. It is hard to believe that this reduces to a mere unconscious and actually apparent fight for chemical survival. In TGD Universe consciousness would be involved even at the molecular level and magnetic body would be the choreographer whose dance would induce the molecular activities. This picture combined with the idea of standard plugs and terminals at which flux tubes end, leads to a to a picture allowing to formulate a model for protein folding.

13.2.1 Flux Tubes As A Correlates For Directed Attention

Molecular survival is the standard candidate for the fundamental variational principle motivating the molecular intentional actions. There is entire hierarchy of selves and the survival at the higher level of hierarchy would force co-operation and altruistic behavior at the lower levels. One might hope that this hypothesis reduces to Negentropy Maximization Principle [K70], which states that the information contents of conscious experience is maximized. If this picture is accepted, the evolution of molecular system becomes analogous to the evolution of a society.

Directed attention is the basic aspect of consciousness and the natural guess would be that directed attention corresponds to the formation of magnetic flux tubes between subject and target. The directedness property requires some manner to order the subject and target.

1. The ordering by the values of Planck constant is what first comes in mind. The larger space-time sheet characterized by a larger value of Planck constant and thus at a higher level of evolutionary hierarchy would direct its attention to the smaller one.

2. Also the ordering by the value of p-adic prime characterizing the size scale of the space-time sheet could be considered but in this case directedness could be questioned.

3. Attention can be directed also to thoughts. Could this mean that attention is directed from real space-time sheets to p-adic space-time sheets for various values of primes but not vice versa? Or could the direction be just the opposite at least in the intentional action transforming p-adic space-time sheet to real space-time sheet? Perhaps directions are opposite for cognition.

The generation of (wormhole) magnetic flux tubes could be the correlate for the directed attention, not only at molecular level, but quite generally. Metaphorically, the strands of braid would be the light rays from the eyes of the perceiver to the target and their braiding would code the motions of the target to a topological quantum computation like activity and form a memory representation at least. The additional aspect of directed attention would be the coloring of the braid strands, kind of coloring for the virtual light rays emerging from the eyes of the molecular observer. In the case of DNA this can induce a coloring of braid strands emerging from amino-acids and other molecules so that it would indeed become possible to assign to free amino-acid the conjugate of the codon XYZ coding for it.

Attention can be also redirected. For this process there is a very nice topological description as a reconnection of flux tubes. What happens is that flux tubes $A \to B$ and $C \to D$ fuse for a moment and become flux tubes $A \to D$ and $C \to B$. This process is possible only if the strands have the same color so that the values of the quark charges associated with A and B are the same.

1. Reconnection process can modify TQC programs. For instance, in the case of the flux tubes coming from nucleotides X and X_c and ending to the lipid layer this process means that X and X_c and corresponding lipids become connected and genome builds memory representation about this process via similar link.

2. Reconnection process makes also possible what might be called color inheritance allowing amino-acids to inherit the conjugate colors of the nucleotides of the codon coding it.

3. DNA would have memory representation about molecular processes via these changing braiding topologies, and one could say that these molecular processes reflect the bodily motions of the magnetic body. Entire molecular dynamics of the organism could represent an enormous TQC induced by the motor activities of the magnetic body. At the level of sensory experience similar idea has been discussed earlier [K110]: out of body experiences (OBEs) and illusions such as train illusion could be understood in terms of motor action of magnetic body inducing virtual sensory percepts.

Attention can be also switched on and off. Here the structure of the lipid ends containing two nearby situated $= O$: s suggest the mechanism: the short flux tube connecting $= O$: s disappears by reconnection mechanism with a pair of hydrogen bonded water molecules leading to a shortcut of the connecting flux tubes to $= O - -H_2O$ hydrogen bonds. The minimization of Coulomb interaction energy at each end implies that re-appearance of the flux tubes creates a short flux tube with the original strand color.

13.2.2 Does Directed Attention Generate Memory Representations And TQC Like Processes

Directed attention induces braiding if the target is moving and changing its shape. This gives rise to a memory representation of the behavior of the object of attention and also to a TQC like process. A considerable generalization of TQC paradigm suggests itself.

Tqc could be induced by the braiding between DNA and lipids, DNA and proteins via folding processes, DNA RNA braiding and braiding between DNA and its conjugate, DNA and protein braiding. The outcome of TQC would be represented as the temporal patterns of biochemical concentrations and rates and there would be hierarchy of p-adic time scales and those associated with the dark matter hierarchy.

For instance, the protein content of lipid membranes is about 50 per cent and varies between 25-75 per cent so that protein folding and lipid flow could define TQC programs as self-organization patterns. The folding of protein is dynamical process: alpha helices are created and disappear in time scale of 10^{-7} seconds and the side chains of protein can rotate.

The details of the TQC like process depend on what one assumes. The minimal scenario is deduced from the transcription and translation processes and from the condition that magnetic body keeps control or at least keeps book about what happens using genome as a tool. The picture would be essentially what one might obtain by applying a rough model for web in terms of nodes and links. The reader is encouraged to use paper and pencil to make the following description more illustrative.

1. Assume that mRNA and DNA remain connected by flux tubes after transcription and that only reconnection process can cut this connection so that mRNA inherits the conjugate colors of DNA. Assume same for mRNA and tRNA. Assume that amino-acid associated with tRNA has similar flux tube connections with the nucleotides of tRNA. Under these assumptions amino-acid inherits the conjugate colors of DNA nucleotides via the connection line DNA-mRNA-tRNA-amino-acid faith-fully if all links are correspond to quark pairs rather than their superpositions. Wobble pairing for Z nucleotide could actually correspond to this kind of superposition.

2. One can consider several options for the amino-acid-acid DNA correspondence but trial-and-error work showed that a realistic folding code is obtained only if X, Y, and Z correspond to $O - H$, $O =$, and NH_2 in the constant part of free amino-acid. During translation the formation of the peptide bond between amino-acids dehydration leads to a loss of $O - H$ and one H from NH_2. The flux tube from tRNA to $O - H$ becomes a flux tube to water molecule inheriting the color of X so that $O = -NH_2$ of the amino-acid inside protein represents the conjugate of YZ.

3. Hydrogen bonding between $O =$ and NH of n: th and $n + k$: th amino-acids inside alpha helices and n: th and $n + 1$: th amino-acids inside beta strands reduces effectively to base pairing characterized by $Y = Z$ rule. Assuming that flux tube is only a prerequisite for the formation of hydrogen bond, $Y(n) = Z(n + k)$ or $Z(n) = Y(n + k)$ allows the existence of hydrogen bond. The identification of hydrogen bond with flux tube gives a more stringent condition $Y(n) = Z(n+k)$. The first option is favored. Either condition is extremely restrictive condition on the gene coding the amino-acid unless one assumes quantum counterpart of wobble base pairing for mRNA or tRNA-amino-acid pairing in the case of Z nucleotide (as one indeed must do). Note that the $O =$ atom of the amino-acid is in a special role in that it can have hydrogen bond flux tubes to donors and flux tube connections with $O =$: s of other amino-acids, the residues of amino-acids containing acceptors (say $O =$ or aromatic ring), and with the aromatic rings of say ATP.

4. The recombination process for two conjugate DNA-mRNA-tRNA-amino-acid links can transform the flux tubes in such manner that one obtains link between the $= O$: s of amino-acids A_1 and A_2 characterized by Y and Y_c. Besides hydrogen bonding this mechanism could be central in the enzyme substrate interaction. The process would pair tRNAs corresponding to Y and Y_c together to give DNA-mRNA-tRNA-tRNA-mRNA-DNA link providing a memory representation about amino-acid pairing $A_1 - A_2$. One could say that magnetic body creates with the mediation of the genome dynamical TQC programs to which much of the bio-molecular activity reduces. Not all however, since two amino-acid pairs $A_1 - A_2$ and $A_3 - A_4$ can recombine to $A_1 - A_4$ and $A_3 - A_2$ without DNA knowing anything about it. Magnetic body would however know.

5. The constant part of non-hydrogen bonded amino-acid inside protein would behave like Y_cZ_c if amino-acid is coded by XYZ. The $COOH$ end of protein would behave like $X_cY_cZ_c$.

Also flux tubes connecting the residue groups become possible and protein does not behave like single nucleotide anymore. By color inheritance everything resulting in the reconnection process between $O=$ and NH_2 and residues reduces in a well-defined sense to the genetic code.

13.2.3   Realization Of Flux Tubes

The basic questions about flux are following. Where do they begin, where do they end, and do they have intermediate plugs which allow temporary cutting of the flux tube.

Where do flux tubes begin from?

The view about magnetic body as a controller of biological body using genome as a control tool suggests that DNA is to a high degree responsible for directed attention and other molecules as targets so that flux tubes emanate from DNA nucleotides. The reason would be that the aromatic cycles of DNA correspond to larger value of Planck constant. Some chemical or geometric property of DNA nucleotides or of DNA nucleotides of DNA strand could raise them to the role of subject. Aromatic cycle property correlates with the symmetries associated with large value of Planck constant and is the best candidate for this property.

If this picture is accepted then also some amino-acid residues might act as subjects/objects depending on the option. Phe, His, Trp, Tyr contain aromatic cycle. The derivatives of Trp and Tyr act as neurotransmitters and His is extremely effective nucleophilic catalyst. This would make possible more specific catalytic mechanisms through the pairing of Phe, His, Trp, and Tyr with residues having flux tube terminals.

This raises the question about the physical interaction determining the color of the strand emerging from the aromatic cycle. The interaction energy of quark at the end of flux tube with the classical electromagnetic fields of nuclei and electrons of the ring should determine this. The wormhole contact containing quark/antiquark at the throat at space-time sheet containing nuclei and electrons could also de-localize inside the ring. One of the earliest hypothesis of TGD inspired model for living matter was that wormhole Bose-Einstein condensates could be crucial for understanding of the behavior of biomolecules [K125]. Wormhole throats with quark and antiquark at their throats appear also in the model of high T_c superconductivity [K25]. As far as couplings are considered, these wormhole contacts are in many respects analogous to the so called axions predicted by some theories of elementary particle physics. The wormhole contact like property is by no means exceptional: all gauge bosons correspond to wormhole contacts in TGD Universe.

The only manner for the electronic space-time sheet to feed its electromagnetic gauge flux to larger space-time sheets using exactly two wormhole contacts is to use wormhole contacts with $\overline{u}$ and d at their "upper" throat (T, G). For proton one would have $\overline{d}$ and u at their "upper" throat (A, C). The presence of electron or proton at nucleotide space-time sheet near the end of flux tube might allow to understand the correlation. The transfer of electrons and protons between space-time sheets with different p-adic length scale is basic element of TGD based model of metabolism so that there might be some relation.

Acceptors as plugs and donors as terminals of flux tubes?

Standardization constraint suggests that flux tubes are attached to standard plugs and terminals. The explicit study of various biological molecules and the role of water in biology gives some hints.

1. An attractive idea is that $= O$ serves as a plug to which flux arrives and from which it can also continue. For the minimal option suggested by hydrogen bonding $O=$ could be connected to two donors and $O=$ could not be connected to $O=$. The assumption that the flux tube can connect also two $O=$: s represents a hypothesis going outside the framework of standard physics. A stronger assumption is that all acceptors can act as plugs. For instance, the aromatic rings of DNA nucleotides could act as acceptors and be connected to a sequence of $O=$ plugs eventually terminating to a hydrogen bond.

2. Donors such as $O-H$ would in turn correspond to a terminal at which flux tube can end. One might be very naïve and say that conscious bio-molecules have learned the fundamental

role of oxygen and water in the metabolism and become very attentive to the presence of $= O$ and $O - H$. $= O$ appears in $COOH$ part of each amino-acid so that this part defines the standard plug. $= O$ appears also in the residues of Asp, Glu, Asn, Gln. $O - H$ groups appear inside the residues of Asp, Glu and Ser, Thr.

3. Hydrogen bonds $X - H - -Y$ have the basic defining property associated with directed attention, namely the asymmetry between donor X and acceptor Y. Hence there is a great temptation consider the possibility that hydrogen bonds correspond to short flux tubes, that flux tubes could be seen as generalized hydrogen bonds. Quite generally, Y could be seen as the object of directed attention of X characterized by larger value of Planck constant. The assumption that two $O =$: s, or even two acceptors of a hydrogen bond, can be connected by a flux tube means more than a generalization of hydrogen bond the connection with a donor would correspond only to the final step in the sequence of flux tubes and plugs giving rise to a directed attention.

4. This hypothesis makes the model rather predictive. For instance, $N - H$, NH_2, $O - H$ and much less often $C - H$ and $S - H$ are the basic donors in the case of proteins whereas $O =$, $-O-$, $-N = S - S$, $-S^-$ and aromatic rings are the basic acceptors. Reconnection process should be involved with the dynamics of ordinary hydrogen bonding. Reconnection process implies inheritance of the flux tube color and means a realization of the symbol based dynamics. It turns out that this hypothesis leads to a model explaining basic qualitative facts about protein folding.

13.2.4   Flux Tubes And DNA

The model of DNA as topological quantum computer gives useful guide lines in the attempt to form a vision about flux tubes. It was assumed that braid strands defined by "wormhole magnetic" flux tubes join nucleotides to lipids and can continue through the nuclear or cell membrane but are split during TQC. The hydrophilic ends of lipids attach to water molecules and self-organization patterns for the water flow in gel phase induce a 2-D flow in the lipid layer which is liquid crystal defining TQC programs at the classical level as braidings. The flow indeed induces braiding if one assumes that during topological computation the connection through the cell membrane is split and reconnected after the halting of TQC.

The challenge is to understand microscopically how the flux tube joins DNA nucleotide to the phospholipid [I21]. Certainly the points at which the flux tubes attach should be completely standard plugs and the formation of polypeptide bonds is an excellent guide line here. Recall that phospholipid, the TQC dancer, has two hydrophobic legs and head. Each leg has at the hydrophilic end O=C-O-C part joining it to glyceride connected to monophosphate group in turn connected to a hydrophilic residue R. The most often appearing residues are serine, inositol, ethanolamine, and choline. Only three of these appear in large quantities and there is asymmetry between cell exterior and interior.

Let us denote by $= O_1$ and $= O_2$ the two oxygens (maybe analogs of right and left hemispheres!) in question. The proposal is that DNA nucleotide and $= O_1$ are connected by a flux tube: the asymmetry between right and left lipid legs should determine which of the legs is "left leg" and which $O =$ is the "left brain hemisphere". $= O_2$, the "holistic right brain hemisphere", connects in turn to the flux tube coming from the other symmetrically situated $= O_2$ at the outer surface of the second lipid layer. Besides this $= O_1$ and $= O_2$ are connected by a flux tube serving as switch on both sides of the membrane.

During TQC the short $O = -O =$ flux tube would experience reconnection with a flux tube acting as hydrogen bond between water molecules so that the connection is split and $O =$: s form hydrogen bonds. The reversal of this reconnection creates the connection again and halts the computation. The lipid residue R couples with the flow of the liquid in gel phase. Since $= O$ is in question the quark or antiquark at the end can correspond to the DNA nucleotide in question. The necessary complete correlation between quark and antiquark charges at the ends of flux tubes associated with $= O_1$ and $= O_2$ can be understood as being due to the minimization of Coulomb interaction energy.

If one is ready to accept magnetic flux tubes between all acceptors then the aromatic rings of nucleotides known to be acceptors could be connected by a flux tube to the $O =$ atom of the lipid

or to some intermediate $O =$ atom. The phosphate groups associated with nucleotides of DNA strand contain also $= O$, which could act as a plug to which the flux tube from the nucleotide is attached. The detailed charge structure of the aromatic ring(s) should determine the quark-nucleotide correspondence. The connection line to the lipid could involve several intermediate $O =$ plugs and the first plug in the series would be the $O =$ atom of the monophosphate of the nucleotide.

There is a strong temptation to assume that subset of XYP molecules, $X = A, G, T, C$, $Y = M, D, T$ act as standard plugs with X and phosphates connected by flux tubes to a string. This would make possible to engineer braid strands from standard pieces connected by standard plugs. DNA nucleotide XMP would have flux tube connection to the aromatic ring of X and the $O =$ of last P would be connected to next plug of the communication line. If so, a close connection with metabolism and topological quantum computation would emerge. Phosphorylation would be an absolutely essential for both metabolism and buildup of connection lines acting as braid strands. $O = -O =$ flux tubes could also act as switches inducing a shortcut of the flux tube connection by reconnecting with a hydrogen bond connecting two water molecules. This is an essential step in the model for how DNA acts as topological quantum computer.

This picture would fit with the fact that XYP molecules, in particular AMP, ADP, and ATP, appear in bio-molecules involved with varying functions such as signalling, control, and metabolism. $= O$ might act as a universal plug to which flux tubes from electronegative atoms of information molecules can attach their flux tubes. This would also provide a concrete realization of the idea that information molecules (neurotransmitters, hormones) are analogous to links in Internet [K92]: they would not represent the information but establish a communication channel. The magnetic flux tube associated with the information molecule would connect it to another cell and by the join to $= O$ plug having flux tube to another cell, say to its nucleus, would create a communication or control channel.

13.2.5   Introns And DNA-Protein Attachment

An example is the situation in which protein acts as an enzyme attaching on DNA. Suppose that this process effectively reduces to a base pairing between amino-acid and DNA nucleotide. Protein can attach to any portion of DNA. The simplest interaction is the attachment to the gene coding for the amino-acid itself but much more general enzymatic interactions are possible. It must be however noticed that DNA sequence coding for given amino-acid sequences is considerably longer than amino-acid sequence: the sequence coding for 10 amino-acids is about 10 nm long whereas the corresponding straight amino-acid strand is about 4.7 nm long. It is known that DNA can change its conformation from strand during enzyme-DNA action [I142], and the contraction of DNA strand might make possible to have enzyme-DNA interaction involving fusion along several subsequent amino-acids. This kind of mechanism might work also in the case that attachment region corresponds to several exons. There is however no need to assume that subsequent amino-acids are form a contact with DNA.

One can of course ask whether genes containing introns tend to code for proteins which are used for topological quantum computations. Introns, perhaps the repeating sequences with no obvious function, would have at least this useful function but very probably much more useful ones too (they are now known to be transcribed to RNA and TGD suggest that language corresponds to intronic gene expression). The emergence of introns might be somewhat like the emergence of information society.

The folding of proteins tends to be conserved in the evolution whereas primary structure can change quite a lot apart from some amino-acids critical for enzymatic action. This confirms with the effective base pairing interaction between amino-acids and DNA to be discussed later and would mean that DNA-amino-acid TQC programs are rather robust against mutations.

13.3   Model For The Folding Code Based On Interactions Mediated By Flux Tubes Between Amino-acids

The model for the protein folding to be discussed in this section relies on the hypothesis that dark flux tube connections between amino-acids and their contractions in $\hbar$ changing phase transitions

determine the dynamics of the folding. A model in which flux tubes between amino-acids and water molecules alone induce the interactions between amino-acids will be discussed in separate section. A realistic model might involve both kind of flux tubes.

13.3.1 4-D Spin Glass Energy Landscape And Code Of Catalytic Action

There is a proposal that protein folding corresponds to a motion in a fractal spin glass energy landscape in presence of external perturbations due to the presence of water and leading to the bottom of some deep valley [I108, I108]. In TGD framework 3-D spin glass landscape is replaced by 4-D one [K98]. The vacuum degeneracy of Kähler action implies 4-D spin glass energy landscape in the sense that quantum jump sequences lead to space-time sheets representing asymptotic self organization patterns depending only weakly on the initial conditions (with respect to subjective time measured as quantum jumps). Proteins would be like skilled musicians possessing a repertoire of motor activities represented by deep valleys in 4-D spin glass landscape.

This picture generalizes to the functioning of living matter in various scales and the quantum dynamics of brain is a natural application giving also connection with p-adicity since ultra-metric topology is naturally associated with the space of valley bottoms. In the case of catalytic reactions a quantum jump changing Planck constant for some magnetic flux tubes connecting some living biomolecules (DNA, RNA, amino-acids, water(?), ..) and changing the lengths of these flux tubes could be the basic mechanism leading from a given valley to a new one and the reduction of the genetic code to single nucleotide or di-nucleotide code would code this quantum jumps.

To me this proposal for the folding code - or rather, the code of entire biocatalysis - looks so beautiful that it deserves to be killed this should be easy for a professional biochemist. If the hypothesis survives, it would provide a royal road to the understanding of the catalytic bio-chemistry.

13.3.2 Flux Tubes And Amino-Acids

Matter antimatter asymmetry at the level of interactions of amino-acids

The first thing that I learned was that in the case of amino-acid belonging to protein interior second nucleotide Y in the codon XYZ coding for amino-acid is what matters. Only $Y = A, G$ amino-acid residue can form hydrogen bonds and is hydrophilic and thus interacts strongly with water and DNA and RNA. In T, C case the formation of hydrogen bonds is impossible or rare (ser, thr). In their interactions with water these amino-acids are passive, or rather-avoid water-and tend to interact with each other. This division is fundamental for the understanding of the interactions of amino-acids. The division of amino-acids to hydrophobic *resp.* non-hydrophobic ones corresponds to the assignment of quarks to A and G and antiquarks to T and C so that strong matter antimatter asymmetry is in question. Similar asymmetry appears in cosmology: in TGD Universe antimatter resides inside cosmic strings in the interior of big voids containing matter as galaxies at their boundaries so that one can understand why antimatter is not visible.

Flux tubes can connect with all electronegative atoms

The model for di-nucleotide precursor code [K47, K48] involves precursors for which 3 precursors contain only oxygen ions or double bonded oxygens. The only possible conclusion is that oxygen can connect to any DNA letter (quark or antiquark) and that first letter-precursor correlation is a selection of the most probable alternative. Also in water oxygen atoms should form flux tube contacts with each other and amino-acids and DNA. Also nitrogen atoms might form similar flux tube connections and this was assumed in the model. Same would apply to sulphur appearing in met and tyr and to electronegative atoms in general.

What can one learn from the formation of alpha helices and beta sheets?

Assume that hydrogen bonds correspond to flux tubes. The formation of peptide bonds by the elimination of H_2O-molecules and generation of hydrogen bonds between $N - H$ and $O =$ is an essential step in the formation of alpha helices and beta sheets. Second observation is that free amino-acids decompose naturally into three parts corresponding to $O = COH$, R, and NH_2. One

can also count $O =$ as a separate unit so that there would be four units in this case. This suggests that amino-acid could correspond to the entire DNA codon XYZ coding for it. In this case there would be 2 flux tubes per amino-acid and one can consider the following options.

1. Y could correspond to either R or $O =$. If hydrogen bonds correspond to flux tubes, $R - Y$ correspondence is not realistic. The reason is that R should be either donor or accept and hydrophobic amino-acids do not possess neither property. Hence only $O =$ can corresponds to Y.

2. $O - H$ could correspond to Z, $O =$ to Y, and NH_2 to X. For this option the amino-acid in protein would correspond to XY. If one identifies hydrogen bonds as special case of flux tubes, the hydrogen bonds of alpha helix would obey $X - Y_c$ rule which seems too restrictive.

3. $O - H$ could correspond to X, R or $O =$ to Y, and NH_2 to Z. For this option the amino-acid in protein would correspond to YZ. In this case the hydrogen bond of alpha helix would obey $Y = Z_c$ rule which by the isospin symmetry of the last nucleotide of the codon might be flexible enough.

Interactions of proteins with ions and electrons

Proteins interact also with electrons and ions. Typical process are the addition or removal of proton, electron, ion such Ca^{++}, or molecule such as O_2. These interactions are not well understood. For instance, the interactions involve the transfer of electrons between ligand protein and protein inducing oxidation (electron is given), reduction (electron is received) or redox reaction (both reduction and oxidation take place). In metabolism redox process is central. These reactions are reversible and it is difficult to understand how electrons are able make their long journey from the interior of the ligand so fast and avoiding dissipative effects. The formation of cyclotron Bose-Einstein condensates of bosonic ions and electronic Cooper pair condensates at the magnetic flux tubes connecting ligand and protein might provide the solution of the mystery. Note that the new nuclear physics predicted by TGD predicts nuclei which can have anomalous em charge associated with the color fluxtubes connecting nucleons to nuclear string so that fermionic ions Na^+, Cl^-, K^+ could have exotic bosonic counterparts.

13.3.3 Trying To Identify The Folding Code

The basic question is what kind of generalized pairings are realistic for amino-acids. The identification of hydrogen bonds as flux tubes leads to rather unique identification of the pairing and excludes the naïvely expected $Y - Y_c$ pairing.

A trial for the folding code

Protein folding code is something which is expected to exist but is not understood [I136]. This inspired a work which led to several trials for the folding code. Also a natural generalization to a code for catalysis emerged. In the most plausible candidate for the code flux tubes are identified as correlates of directed attention at molecular level. By their asymmetry hydrogen bonds are identified as a special case of flux tubes. Free amino-acid behaves like $X_cY_cZ_c$ and the amino-acid inside protein like Y_cZ_c. There are *two flux tubes* per amino-acid corresponding to $N - H$ and $O =$ representing Z_c and Y_c.

This leaves two options for pairing.

1. If $O =$ can act as a terminal for hydrogen bond and long flux tube then $N - H$ and Y can connect simultaneously to $O =$ and one has $Y = Z$ pairing.

2. If $O =$ can act as a terminal for only single flux tube representing Y then reconnection process for $N - H$ and $O =$ flux tubes creates the hydrogen bond and $Y = Z_c$ pairing for amino-acids results

Both pairings are highly flexible so that obvious inconsistencies with the data about alpha helices and beta sheets are avoided. A highly non-trivial and testable prediction of both pairings

is that the two identical proteins coded by different DNA sequences can have different foldings since the allowed pairings are not identical. Thus amino-acids would remember at the level of the braidings which DNA sequence coded them. This prediction can be avoided only Z flux tube corresponds to a quantum superposition of the nucleotides coding for the amino-acid in question so that one has quantum superposition over quark pairs associated with the third nucleotide.

The two-point mutations possibly carried out intentionally by the magnetic body controlling the genome conserving amino-acid pairings by hydrogen bonds and thus perhaps also folding and the catalytic properties should transform $Y = Z_c$ ($Y = Z$) pair to an allowed pair of this kind so that quite wide repertoire of allowed 2-point mutations is available for this option.

$Y = Z_c$ or $Y = Z$ pairing might work

The isospin symmetry of the third nucleotide implies that $Y = Z_c$ pairing is quite flexible. Roughly, the rule would allow flux tube connections only between amino-acids for which Y and Z correspond to quark and antiquark. The amino-acid pairs can be classified to three types. The amino-acid pairs for which both amino-acids can act as acceptors and donors, the pairs for which amino-acids can act only as an acceptor or donor, and the pairs for which no flux tubes are possible.

There are two options to be considered.

Option 1: Flux tube in either direction between amino-acids is prerequisite for the existence of the hydrogen bond. In this case the condition is $Y(n) = Z(n + k)$ or $Z(n) = Y(n + k)$.

Option 2: Hydrogen bond is identified as a flux tube. The condition is $Y(n) = Z(n + k)$ and thus stronger than for the first option.

Table 13.1 of Appendix summarizes the allowed and non-allowed pairings for $Y = Z_c$ and $Y = Z$ pairings. To understand the tables some notation conventions must be introduced.

1. Let X_{ij} denote the amino-acids in i: th and j: the column of the code table. $i, j = 1, 2$ corresponds to hydrophobic amino-acid residues and $i, j = 3$, 4 to hydrophilic amino-acid residues.

2. For $Y = Z_c$ option the sets t, T, U, V, W, X are defined as $t = \{phe\}$, $T = X_{12} - t$, $U = \{tyr, his, asn, asp, cys, arg, ser, gly\}$, $V = \{trp, gln, lys, glu, gly\}$, $W = \{gln, lys, glu, trp, arg, gly\}$, and $X = \{tyr, his, asn, asp, cys\}$.

3. For $Y = Z$ option the sets t, T, U, V, W, X are defined as $t = \{met\}$, $T = X_{12} - t$, $U = \{trp, gln, lys, glu, arg, gly\}$, $V = \{tyr, his, asn, asp, cys\}$, $W = \{tyr, his, asn, asp, cys, arg, ser, gly\}$, and $X = \{gln, lys, glu, trp\}$. ser has been excluded from V since it appears also in the second column of the code table.

Some clarifying comments about the table are in order.

1. Pro is an exception since Z nucleotide cannot be represented in this case and Pro can act as donor. This has not been taken into account in the tables.

2. The codons coding for the paired amino-acid give additional strong limitations on the pairing unless Z corresponds to quantum superposition of quark pairs associated with the third nucleotide for the codons coding for the amino-acid.

3. Depending on option either phe-phe or Met-Met hydrogen bonding is forbidden so that for hydrophobic amino-acids almost all pairings are possible. This might allow to select between the two options or kill both. The special role of met suggest that $Y = Z$ pairing might be the right option. Also the model for DNA as TQC assumes that $O =$ associated with lipids can act as a plug to which two flux tubes terminate. On the other hand, phe is also exceptional in the sense that it is the only amino-acid in X_{12} which has aromatic ring and can act as an acceptor.

4. The amino-acids which can act simultaneously as donors and acceptors are of special interest as far interactions between catalyst sites of protein and ligand are considered. Second flux tube could be involved with the structure of the catalyst site and second flux tube with the bonding of between catalyst sites. This kind of amino-acids correspond to $T \times T$, $U \times$

U, $X_{12} \times W$. For both options hydrophobic amino-acid can be connected with any other hydrophobic amino-acid. In the case that the two amino-acids are connected by two flux tubes one has stronger conditions giving $(Y_1, Z_1) = (Z_2, Y_2)_c$ or $(Y_1, Z_1) = (Y_2, Z_2)$.

5. $T \times t$, $U \times V$, and $T \times X$ correspond to pairings for which amino-acids can act as donor or acceptor only. The triplets abc in which (a, b) belongs to one of these sets should not appear in alpha helices. For instance, for $Y = Z$ pairing hydrogen bonded $xmety$ triplets with x, y in X_{12} should not be possible.

6. The hydrogen bonds of alpha helices and beta sheets provide a test for the model. For instance, the appearance of gly in the hydrophobic portions of alpha helices is consistent with both $Y = Z_c$ and $Y = Z$ pairing. The alpha helix appearing as an example in [I142] is consistent with both options.

2. Flux tube is identified as hydrogen bond

Table 13.2 of Appendix summarizes the allowed and non-allowed pairings for $Y(n) = Z_c(n + k)$ and $Y(n) = Z(n + k)$ pairings in this case. The notational conventions are following.

1. Let X_{ij} denote the amino-acids in i: th and j: th column of the code table. $i, j = 1, 2$ corresponds to hydrophobic amino-acid residues and $i, j = 3, 4$ to hydrophilic amino-acid residues. Only the sets X_{12} and X_{23} are of interest.

2. For $Y = Z_c$ option the sets t_1, t_2, V, W are defined as $t_1 = \{phe, pro\}$, $t_2 = \{met, pro\}$, $V = \{trp, gln, lys, glu\}$, and $W = \{tyr, his, asn, asp, cys\}$.

3. For $Y = Z$ option the sets t_1, t_2, V, W are defined as $t_1 = \{met, pro\}$, $t_2 = \{phe, pro\}$, $V = \{tyr, his, asn, asp, cys\}$, and $W = \{trp, gln, lys, glu\}$. ser has been excluded from V since it appears also in the second column of the code table.

Some clarifying comments about **Table 13.1** are in order.

1. The two options are related by the duality $t_1 \leftrightarrow t_2$, $V \leftrightarrow W$. Pro appears in the list because it contains no $N - H$ group and cannot therefore act as donor. The fact that Pro often appears as first amino-acid in alpha helix conforms with this.

2. The codons coding for the paired amino-acid give additional strong limitations on the pairing unless Z corresponds to quantum superposition of quark pairs associated with the third nucleotide for the codons coding for the amino-acid. This could be interpreted as counterpart of wobble base pairing.

3. Met (contains S), pro, and phe (only amino-acid with aromatic ring in X_{12}) are exceptional for both options. $X_{12} \times t_1$ and $X_{34} \times t_2 = O - -(H - N)$ hydrogen bonding is forbidden. This poses strong conditions at the boundaries of hydrophilic and hydrophobic regions.

One might hope that either of these models could give a solution to the basic problem of proteonics whether genes code for the protein folding and how: the apparently lost information in the mapping of codons to amino-acids codes for the folding determined hydrogen bonds and more general flux tubes. The hydrogen bonds of alpha helices and beta sheets provide a test for the model. In absence of quantum counterpart of wobble base pairing for Z both models allows to deduce from the mere amino-acid sequence and hydrogen bonding the DNA sequence coding for the protein in the case of alpha helices and presumably also beta sheets. This is of course a testable prediction. For non-hydrogen bonded portions of protein this might not be possible and an interesting question is whether they tend to consist of amino-acids in sets t, V and $t \cup X$ so that hydrogen bonds are not allowed. In any case this would mean a solution to the basic problem of proteomics whether genes code for the protein folding and how: the apparently lost information in the mapping of codons to amino-acids codes for the folding determined hydrogen bonds and more general flux tubes.

Tests for $Y = Z$ and $Y = Z_c$ pairings

The test consists of deducing the number N of pairs which did not satisfy the condition $(a(ii), a(ii + 4))$ not equal to (t, t), or does not belong to $(V \times V)$ or to $t \times V$). From this the average length L of portions satisfying alpha helix conditions $k = 4$ can be deduced as $L = N/N_{tot}$, where N_{tot} is the number of amino-acids in the sequence.

The test was carried out for one structural unit of asparagine synthetase [I2], xylose isomerase [I31], hydrolase [I17], glutathione s-transferase [I15], and restriction endonuclease BamHI [I4].

1. Option 1: Flux tube from in direction is prerequisite for the formation of hydrogen bond

From **Table 13.6** of Appendix one finds that the test for values of k different from $k = 4$ for helix gave also surprisingly large values of $L(k)$ for $Y = Z$ option. The average length of alpha helix is 10 amino-acids so that both options could work. $Y = Z_c$ option gives results rather near to this value.

One can apply test also to individual alpha helices. For asparagin synthethase alpha helices correspond to the intervals [7, 28], [76, 84], [130, 155], [170, 177], [76, 84], [170, 177], [182, 194], [256, 268], [277, 284], [297, 305], [309, 314], and [320, 326] in the standard numbering of amino-acids. The test was done for $k = 3, 4, 5, 6$ assuming that the upper end of tested interval is 6 units higher. $N = (0, 0, 0, 0)$ results for both options for all intervals except for the interval [7, 28] for $Y = Z_c$ for which one obtains $N = (4, 2, 3, 3)$. Hence $Y = Z$ option is favored.

In the case of remaining enzymes only long enough alpha helices were tested and **Table 13.4** of Appendix gives the results

The conclusions are following.

1. From **Table 13.4** it seems clear that $Y = Z_c$ option does not work satisfactorily whereas $Y = Z$ option has rather few failures.

2. In the case of xylose isomerase and $(Y = Z)$ option with $k = 4$ there are four helices for which failure occurs for single amino-acid. The prediction is that the corresponding hydrogen bonds are actually absent.

3. The worst failure occurs for glutathione s-transferase and involves two amino-acids which are at positions n and $n + 4$. The hydrogen bonds are predicted to not exist between met-glu and glu-asp in met-glu-asp.

Beta sheets consist of beta strands which can be regarded as $(n, n+1)$ helices so that stability conditions correspond to $k = 1$. As the **Table 13.5** of Appendix shows, there are no failures for Y=Z option whereas $Y = Z_c$ option has several failures and very bad failure for glutathione s-transferase (3 failures for 4 units long strand).

One might think that loops could contain amino-acids for which the hydrogen bonds to neighbors are not possible. The test for BamHI showed that this is not the case. Only single loop failed for $Y = Z$ option for $k = 1, 2..., 4$ and this occurred for $k = 1$.

The remaining test is for whether the $Y = Z$ pairing indeed can fix the DNA sequence completely. BamHI begins as *met glu val glu lys glu phe ile.....* For beta sheet beginning from second amino-acid requires that the Y=Z rules holds true for subsequent codons in DNA sequence *aag ctt cct taa ttc cgg aag...* [I5]. By comparing the Z of a given codon in beta sheet to the Y of the next codon inside beta sheet one finds that the $Y(n) = Z(n + 1)$ or $Z(n) = Y(n + 1)$ fails. Similar conclusion follows from an analogous check for the first alpha helix. Situation is saved if the quantum counterpart of wobble base pairing is at work so that the flux tube from tRNA to $N - H$ would in superposition of colors (quark pairs) corresponding to superposition nucleotides Z in codons XYZ for given X and Y coding for the amino-acid in question. Hydrogen bonded amino-acid sequence would behave as if it were coded by the unique DNA sequence. Note that for a given amino-acid X is unique except for leu and arg and Y is unique except for ser. The $N - H$: s and $O =$: s for which hydrogen bonds are lacking could form hydrogen bonds with water molecules and $O =$: s could have long flux tubes with other $O =$: s in the protein.

2. Option 2: flux tube is identified as hydrogen bond

Tables 13.7 and **13.8** of Appendix summarize the results of the test for $Y = Z$ and $Y = Z_c$ option when flux tube is identified as hydrogen bond. For the first option the average length of

hydrogen bonded interval would be around 5 amino-acids for $k = 4$ helix for $Y = Z$ and somewhat shorter for $Y = Z_c$. BamHI is exceptional since in this case the length is 16.8 (10.4) amino-acids. for $Y = Z$ ($Y = Z_c$). There is no clear difference between the two alternatives in the case of alpha helices and neither alternative looks promising in this case.

Are $= O - O =$ flux tubes present?

$Y = Z$ option for the folding code assumes that flux tubes can connect acceptor atoms by flux tubes. The pairing would be $Y - Y_c$ pairing considered in the original model as the only possible pairing. In amino-acids only $O =:$ s not acting as acceptors for ordinary hydrogen bonds could have flux tube connections of this kind with each other or other molecules.

1. In the case of amino-acids $Y - Y_c$ pairing would be between amino-acid in X_{12} and amino-acid in X_{34} part of the code table. These connections would be typically associated with the portions of the protein between alpha helices and beta sheets. The $k : th$ amino-acid ($k = 3, 4$ or 5) following Pro would be an exception to this rule and this kind of flux tubes could be involved with the long scale stabilization of proteins.

2. The $O =$ atom would effectively behave like Y_c. Depending on whether it corresponds to quark or anti-quark, the corresponding amino-acid would be typically hydrophilic or hydrophobic- or rather - able to form hydrogen bonds or not. Since hydrophilic and hydrophobic residues tend to avoid each other the flux tubes in question should be rather long. The phase transitions increasing Planck constant might make this possible. This would bring in a strong long range correlation between the dynamics of the amino-acid residues belonging to the first and third (second and fourth) column of the code table.

3. $= O - O =$ flux tubes could be also between different proteins. In the case of protein-ligand complex the Planck constant changing phase transition reducing the length of this kind of flux tube could bring proteins together after which a recombination process the hydrogen bond connecting two water molecules would transform the bond to hydrogen bonds of $O =:$ s with water molecules.

4. The phase transition increasing $\hbar$ would allow hydrophobic amino-acids to increase their distance from water molecules in a controlled manner. This could be essential for folding and make possible the formation of pockets connected by flux tubes of large $\hbar$ to water. In quantum models for evolution of consciousness these pockets are believed to play a prominent role. Molecular sex in this sense would mean a correlation tending to keep partners at large distance except when $\hbar$ reducing phase transition occurs.

Evolution and amino-acid pairings

The evolution at the molecular level corresponds to the emergence of increasingly complex molecules using as basic building blocks amino-acid chains and non-translated residues attached to them in the post-translational processing of the amino-acid chains. Also increasingly complex reaction paths emerge. Molecular survival and the competition for the metabolic resources at molecular level could be seen as the basic driving force of this evolution.

Typically, in the original situation the enzymes would have received the substrate molecules from the environment but sooner or later this would have become difficult. The solution would have been a synthesis of the substrate from simpler ingredients by starting from some precursor.

If molecules (with magnetic bodies included) are conscious entities able to direct attention, one can imagine that magnetic body controlling them with the mediation of genome and able to actively modify it, could help through modifications of the genome to create to the catalyst a binding site able to bind the precursor. Immune system is doing this very intensively. If the enzyme binding the precursor already exists, a combination of genes coding for the enzyme and the enzyme having the metabolites as ligands could allow to achieve this. All this would reduce to the motor activities of magnetic body, in particular reconnection of flux tubes, a kind of dance of Shiva. Genome would not be anymore a sequence of DNA developing through random mutations under selection pressures.

In this framework amino-acids would have appeared before their precursors and possessed some function in RNA world, say the catalysis of join of RNA_2 di-nucleotides to the increasing chain as proposed in [K47, K48]. Competition might have led to a situation in which RNA_2 learned to catalyze selectively the generation of amino-acids from much simpler precursors (three of the proposed precursors contain only C, $= O$, and O^-) giving rise to positive feedback implying an exponential amplification of RNA and amino-acid populations. The reduced genetic code would have been present at two levels. The reader can decide whether this is a shortcoming of the model or a fundamental biochemical duality.

Can one make any clear cut predictions about preferred mutations?

1. In TGD framework mutations are not expected to be always random point mutations but could be even a result of a purposeful action of the magnetic body. Chemical similarity is expected to be conserved in good mutations. This is known to be the case. For $Y = Z$ or $Y = Z_c$ pairing the simplest mutations should leave both Y and Z invariant so that only the first nucleotide X can suffer a mutation.

2. Also bi-local mutations of the second and third nucleotides of codons forming $Y = Z$ ($Y = Z_c$) pair and conserving this property might occur and could be crucial for the coherence of the organisms. As found, the formation of flux tube between amino-acids A_1 and A_2 induces a flux tube between nucleotides Y and Z at the corresponding genes. This flux tube could force the possibly intentional mutations to occur as simultaneous mutations of the two genes so that $Y = Z$ ($Y = Z_c$) condition remains true for amino-acids connected by flux tube.

3. A new element is that isospin rotation of Z nucleotide ($A \leftarrow G$, $T \leftarrow C$) which does not affect amino-acid, affects its folding so that same protein might have different folding patterns and different catalytic properties corresponding to different codons coding for it. This would mean a breaking of the central dogma a the level of magnetic body. Some examples are in order. The mutations Ala/Ser, Ser/Thr, Ile/Val/Leu, Asp/Glu do not change Y. Lys/Arg (A/G)), Tyr/Phe (A/U), gly/Ala (G/C), ... are also prevalent and one might hope that they correspond to binary mutations in some important cases.

4. Folding is known to be more conserved than amino-acid sequence [I142]. Since folding is a collective property of gene, local chemistry might not be enough and the proposed non-local conservation laws might be needed. Two-point mutations would also correlate the mutations of the binding sites of protein and ligand. For the model assuming two flux tubes per amino-acid, the prediction would be conserved $Y = Z$ ($Y = Z_c$) pairs in genes coding for protein and ligand and these pairs might allow to deduce the paired points. This is consistent with the fact that hydrophobic (-philic) regions tend to be paired in the protein-ligand complex. The paired nucleotides need not belong to the same strand since genes are evenly distributed between strand and its conjugate and characterized by A, G surplus.

5. If the flux tubes can connect also side chains, the situation becomes more complex. There is a temptation to think that these flux tubes would connect only the nearby amino-acids of the same peptide and do not therefore affect the large scale dynamics of folding. This would be the case if the value of Planck constant associated with these flux tubes is smaller than for the flux tubes connecting amino-acids as basic units. If flux tubes can begin from the aromatic side chains, the replacement of an aromatic side chain with an aromatic side chain is favored (also chemical similarity explains this). The most basic facts about folding do not provide obvious support for the idea about flux tubes between residues.

    (a) Hydrophobic residues tend to cluster in dense packing in protein interior (antimatter at quark level) and Val (T), Leu (T), Ile (T), Phe (T), Ala (C), and gly (G) make 63 percent of the interior of protein: the special role of gly (matter rather than antimatter at quark level) is due to the reduction of the side chain to hydrogen atom.

    (b) Asp (A), Glu (A), Lys (A) and Arg (G) with ionized residues are mostly at the surface of protein and make 23 per cent of protein surface and 4 per cent of interior. As noticed earlier, matter and antimatter at quark level tend to be far from each other. This is consistent with $Y = Z$ pairing between nearby amino-acids and absence of flux tubes between matter and antimatter if there are two flux tubes per amino-acid.

(c) Polar groups tend to be paired by hydrogen bonds and oppositely charged groups tend to be near each other. Acidic Cys residues tend to be in positions where they can form $S - S$ bonds. This can be explained as being induced by $Y - Y$ pairing in the proposed scenario. Aromatic residues tend to have favorable electrostatic interactions with each other and with S, O and amino groups.

13.4 A Simple Quantitative Model For Protein Folding And Catalyst Action Assuming Flux Tubes Between Amino-Acids

Levinthal paradox states that if protein folding is a process in which protein checks for all possible conformations, folding would take astrophysical time. Small single domain proteins with lengths below 100 residues however fold in single step in millisecond time scale and longest folding times are measured in days. This suggests that protein folding is in some sense guided dynamical process and flux tubes would be the natural guides.

It is possible to construct a simple quantitative model for protein folding and catalyst action assuming a long range interaction mediated by flux tubes between amino-acids obeying base pairing rule in some sense. A further assumption is that hydrogen bonds correspond to flux tubes. There are two options to consider.

1. If there is only single flux tube per amino-acid the rule implies that conjugate amino-acids are connected by a flux tube: this is conflict with the empirical facts.

2. If there are two flux tubes per amino-acid base pairing predicts that amino-adic pairing obeys $Y = Z$ or $Y = Z_c$ rule depending on whether $O =:$ s can act as intermediate plugs for flux tubes or not.

The model is consistent with quantum criticality, and the general vision about 4-D spin glass landscape. The extremals are not completely deterministic just as vacuum extremals of Kähler action and only absolute minimization of energy selects minima. The cautious interpretation is that absolute minimization of energy stabilizes various unstable patterns generated spontaneously by ordinary chemical interactions such as alpha helices and beta sheets. The interpretation of hydrogen bond in terms of flux tube suggests more bold interpretation.

The principle is flexible enough to carry out this purpose but also poses strong constraints on how these patterns integrate to higher level structures. The disappearance of a subset of flux tubes does not spoil the extremal property although it increases its non-determinism and makes folding less predictable and in the case of binding sites it reduces the selectivity of catalyst action. The interpretation would be in terms of molecular ageing. The density of flux tubes can be seen as an analog for the resolution of quantum measurement which is in a fundamental role in quantum TGD, as well as a direct correlate for cognitive and sensory resolutions. The model extends to a model of catalyst dynamics if one the relative motion of reactant molecules is slow in the time scale of folding dynamics so that adiabaticity assumption makes sense. In the following I often use the basic data which can be found from [I142] without explicit reference.

13.4.1 The Model

Let us assign potential energy to the flux tube connecting i: th and $k(i)$: th amino-acid and depending only on the distance $r_{i,k(i)}$. What comes in mind first is the potential energy of harmonic oscillator:

$$V(r) \quad = \quad \frac{kr^2}{2} \quad . \tag{13.4.1}$$

$k > 0$ corresponds to harmonic oscillator. Also $k < 0$ is possible in which case the distance between amino-acid and its conjugate tends to be maximized in equilibrium: this option turns out to be the more plausible one and conforms also with the notion of quantum criticality. Besides this there

is the constraint that the distances between amino-acid and its follower are constant: $r_{i+1,i} = R$. Using Lagrange multipliers this gives rise to the action

$$L = -E = -\frac{k}{2}\sum_i r_{i,k(i)}^2 + \sum_i \lambda_i r_{i+1,i}^2 \ . \tag{13.4.2}$$

Energy is the negative of this action for static solutions. One could consider also adding kinetic term to this action to describe the dynamics of folding. This action is hoped to give only a qualitative view about folding and the ordinary chemical interactions should fix the details of the folding and select between different folding patterns. Several amino-acid chains could be present and have mutual long range interactions.

If $N - H$ and $O =$ both can be connected by flux tubes, each amino-acid gives two terms to the energy corresponding to the flux tube beginning from $N - H$ and flux tube ending at $O =$.

The extremals of this action satisfy

$$\frac{\partial L}{\partial r_i^k} = 0 \ , \quad i = 1, ..., N \ . \tag{13.4.3}$$

1. If there is only *single flux tube per amino-acid*, this gives the conditions

$$\begin{aligned}
\lambda_{i+1}\bar{r}_{i+1,i} - \lambda_{i-1}\bar{r}_{i,i-1} &= -k\bar{r}_{i,k(i)} \ , \\
r_{j+1,j} &= R \ .
\end{aligned} \tag{13.4.4}$$

The geometric content of these conditions is that the vectors $\bar{r}_{i,k(i)}$, $\bar{r}_{i+1,i}$, and $\bar{r}_{i,i-1}$ are in the same plane.

2. If there are *two flux tubes per amino-acid* $(= O_i -\!-(N-H)_{k_1(i)}$ and $(N-H)_i -\!-(O =)_{k_2(i)})$

$$\begin{aligned}
\lambda_{i+1}\bar{r}_{i+1,i} - \lambda_{i-1}\bar{r}_{i,i-1} &= -k[\bar{r}_{i,k_1(i)} + \bar{r}_{i,k_2(i)}] \ , \\
r_{j+1,j} &= R \ .
\end{aligned} \tag{13.4.5}$$

In this the resultant of the vectors $\bar{r}_{i,k_1(i)} + \bar{r}_{i,k_2(i)}$ would be in the plane determined by $\bar{r}_{i+1,i}$ and $\bar{r}_{i,i-1}$. Note that due to the lack of $N - H$ in Pro it can happen that there is only single flux tube per amino-acid.

Long range interactions of amino-acids with their conjugates would dictate the local folding of the amino-acid chain but extremum property alone does not say much about the lengths of the flux tubes.

Suppose that $\bar{r}_i$, $\bar{r}_{i,k(i)}$, $\bar{r}_{i,i-1}$, λ_{i-1} are known. Can one solve λ_{i+1} and $\bar{r}_{i+1,i}$? Since the vectors are in the same plane, the linear dependence does not fix the direction of $\bar{r}_{i+1}$ in this plane but only the value of λ_i in this plane once $\bar{r}_{i+1}$ is fixed or vice versa. Therefore the direction in the plane remains un-determined and equations of motion are not fully deterministic as far as extremals are considered. Absolute minimization however eliminates this non-determinism by maximizing the distances $r_{i,i(k)}$ for $k > 0$ option. The expressions for λ_i result from elementary linear algebra by introducing dual basis of non-orthogonal basis defined by $\bar{r}_{i,k(i)}$ and $\bar{r}_{i,i-1}$.

1. In the case that there is *single flux tube per amino-acid*, one has

$$\lambda_{i+1} = -k\bar{e}_{i+1} \cdot \bar{r}_{i,k(i)} \ , \quad \lambda_{i-1} = -k\bar{e}_{i-1} \cdot \bar{r}_{i,k(i)} \ ,$$

$$\begin{aligned}
\bar{e}_{i+1} \cdot \bar{r}_{i+1,i)} &= 1 \ , & \bar{e}_{i+1} \cdot \bar{r}_{i,i-1)} &= 0 \ , \\
\bar{e}_{i-1} \cdot \bar{r}_{i+1,i)} &= 0 \ , & \bar{e}_{i-1} \cdot \bar{r}_{i,i-1)} &= 1 \ .
\end{aligned} \tag{13.4.6}$$

The non-determinism does not make it easy to find absolute minimum since non-determinism corresponds to circle $(S^1)^{2N}$ for amino-acid sequence with N flux tube pairings. These conditions do not make sense when $\bar{r}_{i+1,i)}$ and $\bar{r}_{i,i-1)}$ are parallel: in this case the force must be parallel to $\bar{r}_{i+1,i)}$.

2. For *two flux tubes per amino-acid* one has a slightly more complex expression for these conditions:

$$\lambda_{i+1} = -k\bar{e}_{i+1} \cdot [\bar{r}_{i,k_1(i)} + \bar{r}_{i,k_2(i)}] \ , \quad \lambda_{i-1} = -k\bar{e}_{i-1} \cdot [\bar{r}_{i,k_1(i)} + \bar{r}_{i,k_2(i)}] \ ,$$

$$\begin{aligned} \bar{e}_{i+1} \cdot \bar{r}_{i+1,i)} = 1 \ , && \bar{e}_{i+1} \cdot \bar{r}_{i,i-1)} = 0 \ , \\ \bar{e}_{i-1} \cdot \bar{r}_{i+1,i)} = 0 \ , && \bar{e}_{i-1} \cdot \bar{r}_{i,i-1)} = 1 \ . \end{aligned} \tag{13.4.7}$$

The strong resemblance with the dynamics defined by Kähler action predicting spin glass degeneracy associated with vacuum extremals of Kähler action and removed by small deformations to non-vacuum extremals raises the hope that the model indeed catches something essential about the notions of 4-D spin glass degeneracy and quantum criticality.

13.4.2   Basic Mathematical Consequences

Consider first the basic consequences of the variational equations.

1. Absolute minimization of energy is very powerful selection principle and expected to choose highly symmetric configurations such as α helices, β sheets, and more complex structures. If combined with adiabaticity assumption it could also allow to understand the dynamics of binding between two proteins and protein and DNA/RNA.

2. The extremals of $k > 0$ action are mirror images of $k < 0$ action so that the energy minimum for $k > 0$ is energy maximum for $k < 0$. If energy minimization is applied also the choice of $Y - Y$ flux tubes, the connected amino-acids should be as near as possible which favors alpha helices and beta sheets. In light of this $k > 0$ option looks the realistic one. It could however be that for large distances the sign of the potential energy changes. For $k > 0$ option long flux tubes are not favored by energy minimization. The simplest cure would be large value of Planck constant changing the scale of the potential. If the potential energy changes sign at large distances the situation changes also and $r_{i,k(i)}$ would be as large as possible subject to the condition from fixed chain length.

3. If the amino-acid is not paired, it does not experience the long range force and one has

$$\lambda_{i+1}\bar{r}_{i+1,i} - \lambda_{i-1}\bar{r}_{i,i-1} \quad = \quad 0 \ . \tag{13.4.8}$$

Situation becomes non-deterministic and the portions of the amino-acid chain for which the amino-acids do not have a pair behave like random coils. This is encouraging since this kind of portions are present in folded amino-acids. The absence of $N - H$ from Pro allows to understand the very special role of Pro as being associated with turns of alpha helices and beta sheets.

4. The disappearance of some flux tubes does not destroy a given solution of the conditions but makes it increasingly non-deterministic. The interpretation as a degradation or ageing at molecular level conforms with the interpretation of braiding as a basic characteristic of life. An attractive interpretation of the density of flux tubes is as correlate for resolution for cognition and sensory perception and motor action as counterpart of measurement resolution which is fundamental notion of quantum TGD.

13.4.3 Model For The Helical Structures

α helix [I142, I1], which is only one member of a rich family of helical structures possible for amino-acid chains, serves as the first test for the model. As a matter fact, the specific properties of α helix are not relevant for the model discussed.

1. α helix has nearly vertical $NH - - - O =$ hydrogen bond between i: th and $i - 4$: th amino-acid. Also $(i, i - 3)$ and $(i, i - 5)$ bondings are possible. There are 3.6 residues per turn so that the basic structural unit has 5 turns and consists of 18 amino-acids. One residue corresponds to a vertical translation of 1.5 Angstrom. The chain contains single amino-acid per length of about 3.8 Angstrom and the angular separation of subsequent amino-acids is 100 degrees in the planar projection.

2. Isolated α helices are not stable but can be stabilized by secondary coiling: their lifetime is of order $10^{-5} - 10^{-7}$ seconds. If the flux tubes are associated with hydrogen bonds, the instability would be naturally due to a reconnection process involving water molecules.

   Consider now the model.

1. Assume that hydrogen bond is accompanied by a special case of a flux tube resulting in the reduction of the value of Planck constant. Short flux tubes (hydrogen bonds) would connect $i - k$: th, i: th and $i + k$: th amino-acids, $k = 3, 4$ or 5. The forces between $i - k$: th and i: th and i: th and $i + k$: th amino-acid compensate each other exactly for an ideal helix so that the conditions are satisfied identically. This kind of mechanism work also for more general helices. $Y = Z$ ($Y = Z_c$) pairing poses special conditions on the helical structures themselves and also on the genes coding for these structures.

2. gly helices are consistent with both $Y = Z$ and $Y = Z_c$ pairings. The spontaneous generation of unstable helices in sequences consisting of mere gly could be understood as the instability of gly-gly flux tubes against reconnection with hydrogen bonds connecting surrounding water molecules. Also the sequences consisting of mere Pro can give rise to unstable helices. Pro does not possess $N - H$ and the residue cannot act as a donor in hydrogen bond. This suggests that the residue of Pro can have flux tubes connecting it to $O =$ but not identifiable as ordinary hydrogen bond.

There are also more complex structures formed form helices [I142]. For coiled coils of two or more alpha helices consisting of repeating heptad unit of 7 amino-acids first and fifth amino-acids tend to be conjugates so that horizontal flux tubes connecting first and fifth amino-acids of neighboring could be responsible for the stability and make also possible the hydrophobic bonding between first and fourth residues. Collagen [I9] is a triplet helix and appears as a basic constituent of bones, tendons, skin, ligaments, blood vessels, and supporting membraneous tissues. The units of collagen triple helix consists of very long repetitive sequences of type $(gly - XY)_n$, with a preponderance of Pro for X (also Lys residues are possible). gly-Pro-Y and gly-X-Hyp appear often: here X and Y are arbitrary amino-acids (Hyp denotes hydroxyprolin with $O =$ replaced with OH: this transforms Pro from acceptor to donor). Heating of collagen triple helix unfolds it and converts it to gelatin, in which polypeptide chains are dissociated, unraveled and disordered. Cooling regenerates these conformations for short stretches.

Consider as a example collagen triplet helix [I9] having $gly - Pro - Y$ as a repeating unit. Assume $Y = Z$ or $Y = Z_c$ pairing. $Y - Y$ hydrogen bonds are possible if Y belongs to the group T or U. Only phe ($Y = Z_c$) or met ($Y = Z$) is excluded from T. $Y = Z_c$ corresponds to $U = \{tyr, his, asn, asp, cys, arg, ser, gly\}$ and $Y = Z$ to $U = \{trp, gln, lys, glu, arg, gly\}$. This prediction might kill the model. glys can be connected for both options.

1. The first model goes like follows. alpha helix structure is guaranteed by hydrogen bonds between the Y: s inside each collagen unit ($k = 3$). The amino-acids gly_i, $i = 1, 2, 3$, are connected by almost horizontal flux tubes cyclically as $gly_1 - gly_2$, $gly_2 - gly_3$, $gly_3 - gly_1$. This cyclic bonding would induce the coiling of alpha helices. The free $O =$: s of Pros could act as acceptors in the hydrogen bonds with the surrounding water molecules (for instance). For gly-X-Hyp one would have similar structure but Hyp would act as donor in the hydrogen

bonds with water molecules. The objection is that if long hydrogen bonds are possible they would have been observed.

2. Second model is based on the philosophy that coiling is a long range effect and must be due to $= O - O =$ flux tubes. gly ($Y = G$) and Pro ($Y = C$) can be connected for both options but only by single flux tube by the special properties of Pro: this bonding would give $n, n + 4$ hydrogen bond of alpha helix. The simultaneous presence of $n, n + 3$ $Y - Y$ bonds and $n, n + 4$ pro-gly bonds might be made possible by coiling. Hence the free $O =$ in gly could be connected with a similar $O =$ in the neighboring strand. $gly_1 - gly_2$, $gly_2 - gly_3$, $gly_3 - gly_1$ cannot form a closed cycle but the repeating helical pattern $gly_1 - gly_2$, $gly_3 - gly_1$, $gly_2 - gly_3$ is possible and could produce the coiling.

13.4.4   Model For β Sheets

beta strands are typically 4-5 amino-acids long structures. Hydrogen bonds are of type $(n, n + 1)$ and β strands have 2 amino-acids per turn so that $\overline{r}_{i-1,i}$ and $\overline{r}_{i,i+1}$ span a vertical plane and the equations of the model are trivially satisfied. beta strands as such are not stable. beta sheets [I6] consisting of β strands which can be either parallel or antiparallel and are glued together by the interactions between residues. beta sheets are also slightly twisted which relates to the chirality of amino-acids. In the antiparallel case strand returns back and forms at the ends of sheet a loop so that so called β hairpin is formed. In parallel case the strand returns as alpha helix to the lower end of the sheet. At the time of writing of [I142] the mechanism of formation of β sheets was not understood.

If horizontal flux tubes between neighboring strands assignable to hydrogen bonds or =O-O= flux tubes between the residues are responsible for the stabilization of the beta sheet structure, then given residue must have two hydrogen bonds with same length to the amino-acids at right and left so that the contributions from right and left side to the force compensate each other and the force is automatically vertical as implied by the twisting angle of π per amino-acid in beta sheet. For self connecting flux tubes inside loops the force would be in the plane of loop and if the force is repulsive loop like structure is expected.

The slight twisting of beta sheet represents a challenge for the model. TGD predicts large parity breaking and thus the twisting and preferred helicity at the level of principle but it is not clear whether the simplest model can explain the twisting.

13.4.5   Secondary Protein Structures

Protein structures are divided into four classes on basis of their secondary structures [I142, I27]. All these structures are consistent with the general model.

1. (α) containing only α helices, which must stabilize each other by horizontal flux tubes.

2. (β) containing only β sheets both usually antiparallel, which appear always in pairs packing against each other. Horizontal flux tubes connecting the β sheets must act as stabilizers.

3. ($\alpha + \beta$) proteins can contain only single β sheet, usually antiparallel, with α helices clustering together at one or both ends of the β sheet. Antiparallel β sheet stabilizes itself.

4. (α / β) in which sheets and helices interact and often alternate along the polypeptide chain. Single parallel β sheet and so called β barrel, kind of sandwich like structure, are basic examples here. The most spectacular barrel consists of 4+4 parallel β strands with α helices outside the barrel.

Concerning the organization of alpha helices and beta sheets to higher level structures the simplest guess is that the large Planck constant flux tubes connecting random coil portions of the amino-acid sequence with each other or with free $O =$ accompanying Pros. The mere assumption that a given portion of coil has only long flux tubes to distant parts of the protein could explain random coil character. The failure of $Y = Z$ condition implies this too. The notion of long hydrogen bond is somewhat questionable and long flux tubes connecting $= O$: s look more favorable. Also free $O =$: s inside alpha helices and beta strands could be connected in this manner.

13.4.6 Model For Protein-Protein Binding Sites

Binding sites obey geometric complementarity and are known to resemble protein interior being closely packed. This is also taken to mean that amino-acid chains run parallel to the surface although this statement is not made explicitly in [I142]: one could see binding sites as part of interior which is in a direct contact with exterior, somewhat like a sensory organ like eye. The interface between similar sized proteins is large and tends to be flat (not expected if proteins make sharp turns at the interface rather than running parallel to the surface). Various bonds eliminate electromagnetic interactions at the interface.

The basic mechanism of binding would be based on the reduction of Planck constant for the flux tubes connecting amino-acids. The high flexibility of $Y = Z$ and $Y - Z_c$ pairings -especially in the hydrophobic regions in the center of the binding site where it allows all but met-met and phe-phe flux tubes- makes it an excellent candidate for a folding code.

The question is whether complementary of bonded amino-acids should induce the geometric complementary of the binding sites in the proposed model.

1. The binding sites could be connected by only very few flux tubes or flux tubes could connect all amino-acids in a pairwise manner: the first extreme is highly flexible whereas second extreme would produce maximal selectivity. Complementary can thus be partial and its degree is predicted to correlate with the selectivity. The interpretation of disappearance of flux tubes as molecular ageing conforms with the gradual loss of selectivity implying reduced performance of immune system.

2. From the example of [I142] about the interface of identical proteins in the quaternary structure of dimer one learns that the geometrically and physically conjugate interfaces of identical monomers pair to form sandwich like structures via so called isologous and heterologous pairings such that valleys and hills fit. The interfaces are reported to resemble closely packed protein interiors and contain hydrophobic residues in the center and hydrophilic residues at periphery. In the case of identical monomers $Y - Z$ and $Y - Z_c$ pairing is possible for a very wide class of amino-acids. The prediction in the case of identical monomers would be that catalyst sites contain only very few amino-acids in the sets V and t defined previously.

3. Also the flux tubes between $= O$ atoms could be in key role in the protein-ligand interaction. The interfaces can be thought of as cutting protein along its interior: in center there are hydrophobic amino-acids and in periphery hydrophilic ones. The $= O - O =$ flux tubes would connect periphery of A (B) to the center of B (A). The reduction of Planck constant for would reduce the length of these flux tubes and bring protein and ligand close to each other so that hydrogen bond formation between residues could being. In this process the flux tube connecting $O =: s$ could by reconnection transform to two hydrogen bonds connecting $O =:$ s to water molecules. After the catalysis the reverse of this process would occur.

4. For single flux tube between $O =:$ s of amino-acid and ligand the force would be along the line $r_{i,k(i)}$ connecting them, In the improbable case that the amino-acids of protein and ligand are connected by *two* hydrogen bond like flux tubes the force is in the direction of $\bar{r}_{i,k_1(i)} + \bar{r}_{i,k_2(i)}$. The force is predicted to be in the plane spanned by $\bar{r}_{i+1,i}$ and $\bar{r}_{i,i-1}$ for protein and in the corresponding plane for ligand. This is true if the amino-acid sequence at the surface is slightly curved in the direction of the conjugate amino-acid or in opposite direction. This condition is guaranteed by the geometric complementarity.

5. The mechanism for the formation of ligand-protein pairs would be very simple: the binding sites of protein and ligand could be coded by same gene or its mutation respecting the Y so that the formation of copies of gene in DNA would be the simplest mechanism to guarantee the prerequisites for geometric conjugation. Geometric conjugation would result automatically if the flux tubes between interior and periphery of binding site determine its shape.

6. Slow enough relative motion of molecules induces an adiabatic variation of the shapes of the binding sites so that lock and key mechanism becomes dynamical. The simplest possibility is that binding site and its conjugate behave like two eyeballs gazing each other as proteins

move with respect to each other. This is possible if binding sites are separated from the rest of the protein by random pieces of chain. The analogy with eye might be actually deeper: I have proposed long time ago that directed attention in vision has as a space-time correlate flux tubes of topological light rays or both of these. Wormhole magnetic flux tubes might indeed connect perceiver and the object perceived and serve as correlates of attention in macroscopic length scales.

7. Also the hydrogen bonds between residues are important for the protein folding. The donor atoms of the residues can inherit the conjugate of the color of $O=$ and acceptor atoms can inherit the color of $N-H$ by temporary reconnection. Therefore also the hydrogen bonds between residues of hydrophilic residues containing both donor and acceptor atoms would be restricted by the colors of atoms and would reflect genetic code.

8. Geometric and physical conjugation (acids and basics combine in the interface) means that a virtual protein A+B is cut to pieces along the surface in the interior defining the interfaces. Could this chopping of bigger proteins to smaller ones able to bind allow a realization at the level of genome in the sense that glued portions of protein would originate from same gene or its reversed version and thus satisfy $Y = Z_c$ or $Y = Z$ rule approximately? Could also protein interior involve pairings analogous to catalyst and ligand pairings? This would partially explain why protein folding is more sensitive to the mutations in the interior of protein.

13.5 A Model For Protein Folding Based On Flux Tube Connections Between Water Molecules And Amino-acids

The overall feelings about the model just discussed are somewhat mixed.

1. The ideas about flux tube as a correlates for a directed attention and about the connection between hydrogen bond formation and flux tube contraction involving change of Planck constant are attractive. It would be nice if flux tubes between amino-acids could force the portions of amino-acid sequences to form representation about each other in their own geometry. What would be also nice that the notions of finite measurement resolution and cognitive resolution which are fundamental notions of quantum TGD would have direct correlates at the level of flux tube dynamics.

2. The model for protein folding involving only flux tube connections between amino-acids satisfying the proposed selection rules has however failures. This could be due to simple fact that the proposed selection rules are quite too restrictive. Also the flux tube connections between amino-acids and water are important and might even determine the folding patterns to a high degree via the induced secondary interactions between amino-acids.

Second model for protein folding to be discussed represents an extreme in which the flux tube connections between amino-acids and water molecules determined the dynamics of the folding. It seems that this model leads to a realistic qualitative picture about folding. Also quantitative model can be constructed as a straightforward generalization of the model involving only the flux tube connections between selected amino-acids.

13.5.1 Could There Be New Physics Behind Hydrophily And Hydrophoby?

One could accept just as a fact that magnetic flux tubes to the magnetic body of water mediate an interaction which is attractive or repulsive between water molecules and amino-acids and attractive between DNA molecules and water. Accepting that this induces interaction between amino-acids one could proceed to model building without any mention about TGD.

One could also try to dig deeper and ask what might be the origin of this interaction.

1. **Option I**: Could one understand the interaction in terms of phase transitions changing the Planck constant of the magnetic flux tube. The interaction would be repulsive (attractive) would result if the interaction energy increases (decreases) when Planck constant is reduced. Magnetic interaction energy is certainly the best candidate and could also imply the equivalence of the divisor code and dark baryon code.

2. **Option II**: Could hydrophily and hydrophoby be described in terms of em interactions of quarks representing nucleotides in the model of DNA as TQC. For instance, could amino-acids and water molecules be characterized by charges which are of opposite sign for water molecules and hydrophilic molecules and of same sign for water molecules and hydrophobic molecules.

For **Option I**, which represents completely new physics (using the standards of TGD!), the situation looks promising. The magnetic interaction energy assignable to the flux tube is a function of the integers (n_a, n_b) characterizing the corresponding page of the book like structure associated with generalized embedding space - in particular of the Planck constant of the flux tube - and the minimization is performed by keeping the charges of the quarks possibly at its ends fixed. This new physics fits also nicely with the idea that magnetic body controls the living matter by utilizing phase transitions changing Planck constant.

What comes in mind in the case of **Option II** is that the ends of the flux tube carry opposite charges correlating with the codon coding for the amino-acid and giving rise to ordinary gauge interactions. Unfortunately this scenario does not seem to work.

1. It was already found that (denoting codons by XYZ) only $Y = A, G$ type amino-acid residue can form hydrogen bonds and is hydrophilic and thus interacts strongly with water and DNA and RNA. If water end of flux tube corresponds to anti-quarks the attractive interaction between quark and anti-quark at the ends of flux tube could relate to hydrophily. For hydrophobic amino-acids one would have interaction between identical quarks and already Fermi statistics would cause repulsion. In DNA as TQC model based on the coding of A, G and T, C in terms of quarks u, d and their anti-quarks hydrophily-hydrophoby dichotomy corresponds to matter-antimatter dichotomy for quark assigned to the ends of the flux tube. Quarks and anti-quark have opposite charges. Hence the flux tube ends of hydrophilic amino-acids could correspond to quarks and water and hydrophobic ends of flux tubes to anti-quarks. Therefore the DNA as TQC model would predict the needed behavior of the forces. In the case of Gly containing only hydrogen as residue the flux tube might be simply absent.

2. DNA codons A, T, C, G are bases and thus polar and hydrophilic. In the case of DNA charge conjugation for quarks corresponds to the puridine-pyrimidine complementarity corresponding to conjugation of nucleotides. The rule applying in the case of amino-acids would predict T, C to be hydrophobic nucleotides which does not make sense. Therefore it seems that hydrophily and hydrophoby cannot reduce to the interactions of dark quarks and that they only represent conjugation of nucleotides symbolically.

13.5.2   An Improve Model For Protein Folding

To begin with let us summarize some basic facts about protein folding.

1. Hydrophily and hydrophoby play a key role in protein folding and dictate to a high degree the resulting folding patterns. This suggests that one cannot neglect the role of water in the process.

2. Protein folding proceeds from short to long length scales starting with the formation of secondary structures such as alpha helices, beta sheets, and random coil portions and is followed by the formation of tertiary and higher structures.

3. The formation of hydrogen bonds is in a decisive role in the formation of secondary structures. The mechanism leading to their formation might be contraction of magnetic flux tube by a phase transition changing Planck constant.

4. The folding patterns do not depend strongly on the precise primary structure, that is precise amino-acid decomposition which suggests that instead of the detailed chemistry the forces between quarks and anti-quarks mediated by flux tubes is what matter so that hydrophily and hydrophoby would become the basic characterizers of the interaction. The phase transitions changing Planck constant would indeed represent this kind of universal interactions independent of the chemistry.

5. In the first approximation amino-acids could be labeled by a variable telling whether it is hydrophobic, hydrophilic, or neither or these (Gly). This approximation would be broken by special amino-acids which appear in edges if beta sheets (Pro) and Cys which often appear as S-S boded pair in junctions. By bringing in forces depending on the angles between tangent vectors of successive amino-acids and on amino-adics themselves this tendency could be modeled.

13.5.3   A Model For Which The Magnetic Body Of Water Is Involved

The alternative approach to protein folding starts from the general vision about magnetic body containing dark matter as a controller of visible matter in living system. The protein and its magnetic body would be regarded as a living system in itself.

1. Magnetic body must have large number of flux tube contacts to the visible matter. An excellent candidate for the magnetic body is that assignable with water and having flux tube connections to DNA and both hydrophilic and hydrophobic amino-acids. The magnetic body could control and at least fasten the self-organization process leading to the folding pattern which - by applying standard argument - would otherwise take astronomical time otherwise. The two-step attractive connections between all hydrophilic amino-acids would be possible via the magnetic body of water. The non-hydrophilic amino-acids not in direct contact with water are known to be more like passive structural stuff responsible for a fixed structure but not so relevant for the functioning of the bio-molecule. Hydrophily and hydrophoby would reflect the dependence of interaction energy on the value of Planck constant associated with the flux tube mediating the interaction.

2. This picture implies a straightforward modification of the earlier model. The simplest model would minimize a potential function V expressible as a sum $V = V_1 + V_2 + V_3$ of three terms. V_1 would be sum of the values of a universal two-particle potential function $V_{phi,phi}(r)$ for arguments $r_{ij} = |r_i - r_j|$ varying over all hydrophilic amino-acid pairs and giving rise to an attractive force. V_2 would be a sum of a universal two-particle potential function $V_{pho,pho}(r)$ for arguments $r_{ij} = |r_i - r_j|$ varying over all hydrophobic amino-acid pairs. V_3 would be would be sum of the values of a universal potential function $V_{phi,pho}(r)$ for arguments $r_{ij} = |r_i - r_j|$ varying over all pairs of hydrophilic and hydrophobic amino-acids. This potential function would induce a repulsive force. Besides this a constraint force due to the fact that amino-acids form a sequence would be present.

3. The resultant of the forces along lines connecting amino-acids would be parallel to the amino-acid sequence in the mechanical equilibrium. Hydrogen bonds and other bonds are indeed formed between neighboring hydrophilic amino-acids and the contraction of the flux tubes connecting the amino-acids in question to the magnetic body of water could be the mechanism. The model seems to be consistent with the basic qualitative facts about folding. The quantitative testing of the model would require determination of the conformations minimizing the potential function subject to the constraint provided by amino-acid sequence. Here of course the freedom to choose the three functions provides a considerable flexibility and symmetry arguments might allow to pose conditions on the form of these functions.

4. One could also include to the potential function describing a direct interaction with water molecules depending on parameters like pH affecting the folding pattern. The resultant for a given amino-acid would be sum of forces directed from a hydrophilic amino-acids to neighboring water molecules. It is not clear whether the normal component of this force could be compensated by the induced forces between amino-acids in a typical equilibrium

configuration and the formation of hydrogen bonds involving the contraction of the flux tube could be the manner to achieve this.

The alternative model is more complicated numerically than the model discussed and it would require a considerable amount of work to test it. In particular, the three universal potential functions involve free parameters even if one makes simplifying assumptions about their functional form (say simple behavior under scaling).

13.6 A Model For Protein Folding And Catalytic Action

It would be fascinating if the vision about the role of flux tube connections would generalize to interactions of all molecules in living matter. The mere selection rules would mean hidden simplicity behind extremely complex looking interactions in living matter. The model for protein folding and catalytic action discussed in [K10] is the first attempt in this direction. In the following this model is briefly summarized and the improvement of the model inspired by recent considerations is suggested.

13.6.1 Earlier Model For The Folding Code

The model for the evolution of the genetic code led [K47, K48] to the idea that the folding of proteins obeys a code inherited from the genetic code. One can imagine several variants of this code. One of the is that amino-acid behaves like the conjugate Y_c of the middle nucleotide of the codon XYZ coding for it. Conjugation for amino-acids would correspond to the hydrophilic-hydrophobic dichotomy. Also catalyst action could reduce to effective base pairing in this picture chemically and at the level of quarks associated with the flux tube to matter antimatter conjugation. The guess that amino-acid and its conjugate form pairs turned out to be wrong however and after various twists and turns I ended up with the hypothesis that the amino-acid in protein behaves like $Y_c Z_c$ where Z corresponds to third nucleotide for some codon coding for the amino-acid.

It however turned that the model as such is probably too restrictive and not fully consistent in the particular cases studied. In the following this model is discussed briefly and later an improved model for protein folding is proposed.

Flux tubes as correlates of directed attention at molecular level

After some trials one ends up with a general conceptualization of the situation with the identification of ("wormhole") magnetic flux tubes as correlates for attention at molecular level so that a direct connection with TGD inspired theory of consciousness emerges at quantitative level. Whether wormhole flux tubes or ordinary flux tubes are needed is not a completely settled question yet and the attribute "wormhole" will not be used in the sequel. This allows a far reaching generalization of the DNA as topological quantum computer paradigm and makes it much more detailed. The final outcome is very simple quantitative model for both protein folding and catalyst action based on minimization of energy, which seems to be consistent with basic experimental facts as well as general ideas.

What kind of atoms can be connected by flux tubes?

1. Hydrogen bonds play a key role in bio-catalysis but are not understood completely satisfactorily in the standard chemistry. Hence the basic question is whether hydrogen bonds can be regarded as or are accompanied by short (wormhole) magnetic flux tubes: note that the subject-object asymmetry of directed attention would correspond to donor-acceptor asymmetry of they hydrogen bond. If this is the case, the identification of the magnetic flux tube connection as a prerequisite for a hydrogen bond or as hydrogen bond becomes natural. At least the atoms able to form hydrogen bonds could form flux tube contacts so that the model would be very predictive and would conform with the known important role of hydrogen bonds in bio-catalysis.

2. The fact that hydrogen bonds connect base pairs suggests a generalization of the notion of base pairing stating that under some conditions amino-acids coded by XYZ and UY_cV can

behave like base pairs. These amino-acic pairs correspond to pairs of amino-acid residues which are hydrophilic *resp.* hydrophobic and hydrophobic residue do not form hydrogen bonds in general. These flux tubes would thus be more general and in general long. The model for DNA as topological quantum computer requires this kind of flux tubes and they would in general connect atoms or molecules which act as acceptors in hydrogen bonding: $O =$ atom in amino-acid and aromatic ring are basic examples.

3. If one assumes that both $N - H$ and $O =$ associated with the constant part of the amino-acid can act as flux tube terminals and represent Z and Y nucleotides of the codon XYZ coding for the amino-acid, one obtains $Y = Z$ pairing of $O = -O =$ flux tubes are allowed and $Y = Z_c$ pairing if only hydrogen bond like pairings are allowed.

Color inheritance by a reconnection of flux tubes

1. There should exist some mechanism allowing amino-acids to inherit the base pairing property from the tRNAs associated with them so that one can identify amino-acid with the middle nucleotide of the codon coding it. If tRNA middle nucleotide is connected to $O =$ of the amino-acid, this becomes possible since the reconnection of flux tubes preserves the "color" of the flux tubes coded by (A, T, G, C) that is by the quark or anti-quark coding for the nucleotide. The temporary formation of a hydrogen bond between $N - H$ and $O =$ of two amino-acids as in the case of alpha helix would allow $N - H$ to inherit the conjugate of the color associated with $O =$. Alternative interpretation is that this hydrogen bond is possible only if the predetermined color of $N - H$ is consistent with the inherited one. The inheritance of flux tube color would be a completely general mechanism and even the donor atoms in the residues of amino-acids could inherit the color of $O =$ in this manner.

2. A possible interpretation for the fixing of the flux tube color is in terms of quantum measurement selecting one color from quantum superposition in the reconnection process. This would mean that the unitary process can bring superposition back and reconnection process can change the inherited color. The hydrogen bonds between water molecules could correspond to quantum superpositions of different colors. This superposition property might relate to the wobble base pairing phenomenon for the third nucleotide in tRNA.

Folding code

The identification of $N - H$ as a representation for the conjugate of the third nucleotide Z means that amino-acids would remember which codon coded them. If only hydrogen bond like flux tubes are allowed, flux tubes can connect only amino-acids satisfying $Y = Z_c$. If $= O - O =$ flux tubes are allowed $Y = Z$ rule favored by the model of DNA as topological quantum computer follows. The isospin symmetry of the third nucleotide implies that both rules are quite flexible. If one identifies hydrogen bond with flux tube ($Y(n) = Z(n + k)$) the model works badly for both options. If one assumes only that the presence of a flux tube connecting amino-acids in either direction ($Y(n) = Z(n + k)$ or $Z(n) = Y(n + k)$) is a prerequisite for the formation of hydrogen bond, the model works. $Y = Z$ rule is favored by the study of five enzymes: the possible average length of alpha helix is considerably longer than the average length of alpha helix if gene is the unique gene allowing to satisfy $Y = Z$ rule. The explicit study of alpha helices and beta sheets for these enzymes demonstrates that the failure to satisfy the condition for the existence of hydrogen bond fails rarely and at most for two amino-acids (for 2 amino-acids in single case only).

$Y = Z$ rule could mean a solution of the basic problem of proteonics: Do genes determine the folding of proteins and how this would take place? The interpretation would be that the information loss suggested by the many-to-one character of the genetic code is only apparent. The apparently lost information which corresponds to the $A - G$ and $T - C$ symmetries of the third nucleotide codes for the hydrogen bonding and hence for the folding of the protein. The model in its most stringent form is easy to kill since in the case of alpha helices and beta sheets the hydrogen bonding fixes completely the DNA sequence coding for the protein. A weaker variant of the model based on quantum variant of wobble base pairing: in this case there are no conditions on DNA sequence. It turns out that only this variant works. Hence hydrogen bonded amino-acid behave as if they were coded by the unique codon consistent with $Y = Z$ rule.

Quantitative model

The quantitative model relies on the assumption that the contribution of a flux tube connecting two amino-acids to the potential energy depends only on the distance between the molecules in question. The extremals of the total interaction energy are same for any choice of the potential and only the absolute minimum of the interaction energy depends on the choice of the potential. The simplest potential corresponds to harmonic oscillator potential and would explain formation of alpha helices and beta sheets and with the fact that hydrophilic and hydrophobic residues tend to have a large distance and only few flux tube contacts. For large Planck constant also long flux tubes could correspond to attractive harmonic oscillator potential. Also the contribution of other interactions between neighboring amino-acids are expected to be present but are neglected in the simplest model. The model predicts alpha helices and beta sheets, and more generally, periodic structures, as solutions to energy minimization equations.

The model fails to catch completely the basic rules of protein folding, and the predictions are not fully consistent with empirical facts in the cases studied. A model in which the hydrophilic and hydrophobic interactions are mediated by flux tubes between magnetic bodies of the molecule and water molecule and in this manner induce long range interactions between amino-acids - somewhat like the attractive interactions of electrons with ions induce attractive interaction between the members of a Cooper pair - looks more attractive. This model is however computationally much heavier and is not discussed in [K10]. In the sequel a formulation of this model is discussed.

13.6.2 Hydrophily And Hydrophoby Number Theoretically

Amino-acids can be classified to hydrophilic and hydrophobic ones whereas all DNA codons are hydrophilic. Hydrophily and hydrophoby are believed to relate to the standard chemistry alone and this might be the case. One can however just for fun ask whether hydrophily and hydrophoby could have a connection with divisor code, formation of flux tubes connecting the molecule to water molecules, and phase transitions changing the value of Planck constant and changing the length of flux tube. I have discussed this idea already in the model of protein folding [K10].

To simplify the model assume that only single dark page is associated with water molecule and labeled by (n_a^W, n_b^W). Of course, several levels characterized by different integers are also possible and this would bring in additional flexibility. Both hydrophoby and hydrophily would mean interaction mediated by the flux tubes to the magnetic body of water with the sign of the force differing for hydrophilic and hydrophobic amino-acids. There is no need to assume that quarks and anti-quarks generate the interaction. Gly for which the residue is just hydrogen atom does not allow classification as a hydrophilic or hydrophobic which would suggest that it does not have any flux tube connections with the magnetic body of the water. The interaction mediated by flux tubes between amino-acids and water molecules would be analogous to the interaction induced by the interaction between electrons and ions inducing attractive interaction between the members of Cooper pair. It would induce attractive interaction between hydrophilic amino-acids and repulsive interaction between hydrophilic and hydrophobic amino-acids favoring the formation of hydrophilic outer surfaces and hydrophobic inner surfaces.

One could understand hydrophily/hydrophoby dichotomy number theoretically for both options. The discussion of the first option makes clear that also second option is possible to realize.

1. Assume that n_a^W is divisible by all integers n_a^{DNA} associated with DNA codons and thus involves suitable powers of primes $p \leq 19$. It could contain also an integer factor which is product of primes larger than $p = 19$. This is necessary for achieving hydrophily of DNA codons.

2. Hydrophily of DNA codons also requires n_b^W must be proportional to the product of coprime integers n_b^W (primes for the simplest option) assignable to DNA codons. n_b^W could involve also a factor proportional to second integer expressible as product of primes $p > 19$. The simplest option is that this integer equals to 1.

3. For hydrophobic amino-acids integers n_b^A must be of form $mn_b^A = n_b^{DNA} m_b$ such that m_a does not divide n_b^W and n_b^W. This is enough to guarantee that magnetic flux tubes in

either direction are impossible so that hydrophoby is guaranteed in the proposed sense. This definition extends also to other molecules and can be expressed in terms of the integers (n_a, n_b) labeling the magnetic body of the molecule.

4. Second option is obtained by assigning the integer m_b only to Gly which is neither hydrophilic nor hydrophobic.

13.6.3   Could There Be New Physics Behind Hydrophily And Hydrophoby?

One could accept just as a fact that magnetic flux tubes to the magnetic body of water mediate an interaction which is attractive or repulsive between water molecules and amino-acids and attractive between DNA molecules and water. Accepting that this induces interaction between amino-acids one could proceed to model building without any mention about TGD.

One could also try to dig deeper and ask what might be the origin of this interaction.

1. **Option I**: Could one understand the interaction in terms of phase transitions changing the Planck constant of the magnetic flux tube. The interaction would be repulsive (attractive) would result if the interaction energy increases (decreases) when Planck constant is reduced. Magnetic interaction energy is certainly the best candidate and could also imply the equivalence of the divisor code and dark baryon code.

2. **Option II**: Could hydrophily and hydrophoby be described in terms of em interactions of quarks representing nucleotides in the model of DNA as TQC. For instance, could amino-acids and water molecules be characterized by charges which are of opposite sign for water molecules and hydrophilic molecules and of same sign for water molecules and hydrophobic molecules.

For **Option I**, which represents completely new physics (using the standards of TGD!), the situation looks promising. The magnetic interaction energy assignable to the flux tube is a function of the integers (n_a, n_b) -in particular of the Planck constant of the flux tube- and the minimization is performed by keeping the charges of the quarks possibly at its ends fixed. This new physics fits also nicely with the idea that magnetic body controls the living matter by utilizing phase transitions changing Planck constant.

What comes in mind in the case of **Option II** is that the ends of the flux tube carry opposite charges correlating with the codon coding for the amino-acid and giving rise to ordinary gauge interactions. Unfortunately this scenario does not seem to work.

1. In [K10] it was found that (denoting codons by XYZ) only $Y = A, G$ type amino-acid residue can form hydrogen bonds and is hydrophilic and thus interacts strongly with water and DNA and RNA. If water end of flux tube corresponds to anti-quarks the attractive interaction between quark and anti-quark at the ends of flux tube could relate to hydrophily. For hydrophobic amino-acids one would have interaction between identical quarks and already Fermi statistics would cause repulsion. In DNA as TQC model based on the coding of A, G and T, C in terms of quarks u, d and their anti-quarks hydrophily-hydrophoby dichotomy corresponds to matter-antimatter dichotomy for quark assigned to the ends of the flux tube. Quarks and anti-quark have opposite charges. Hence the flux tube ends of hydrophilic amino-acids could correspond to quarks and water and hydrophobic ends of flux tubes to anti-quarks. Therefore the DNA as TQC model would predict the needed behavior of the forces. In the case of Gly containing only hydrogen as residue the flux tube might be simply absent.

2. DNA codons A, T, C, G are bases and thus polar and hydrophilic. In the case of DNA charge conjugation for quarks corresponds to the puridine-pyrimidine complementarity corresponding to conjugation of nucleotides. The rule applying in the case of amino-acids would predict T, C to be hydrophobic nucleotides which does not make sense. Therefore it seems that hydrophily and hydrophoby cannot reduce to the interactions of dark quarks and that they only represent conjugation of nucleotides symbolically.

13.6.4 An Improved Model For Protein Folding

To begin with let us summarize some basic facts about protein folding.

1. Hydrophily and hydrophoby play a key role in protein folding and dictate to a high degree the resulting folding patterns. This suggests that one cannot neglect the role of water in the process.

2. Protein folding proceeds from short to long length scales starting with the formation of secondary structures such as alpha helices, beta sheets, and random coil portions and is followed by the formation of tertiary and higher structures.

3. The formation of hydrogen bonds is in a decisive role in the formation of secondary structures. The mechanism leading to their formation might be contraction of magnetic flux tube by a phase transition changing Planck constant.

4. The folding patterns do not depend strongly on the precise primary structure, that is precise amino-acid decomposition which suggests that instead of the detailed chemistry the forces between quarks and anti-quarks mediated by flux tubes is what matter so that hydrophily and hydrophoby would become the basic characterizers of the interaction. The phase transitions changing Planck constant would indeed represent this kind of universal interactions independent of the chemistry.

5. In the first approximation amino-acids could be labeled by a variable telling whether it is hydrophobic, hydrophilic, or neither or these (Gly). This approximation would be broken by special amino-acids which appear in edges if beta sheets (Pro) and Cys which often appear as S-S boded pair in junctions. By bringing in forces depending on the angles between tangent vectors of successive amino-acids and on amino-adics themselves this tendency could be modeled.

The earlier approach to protein folding inspired by DNA as TQC idea did not start from this picture but assumed that direct flux tube connections between amino-acids rather than the interactions induced by flux tube connections with the magnetic bodies of water molecules were responsible for the folding. The model did not lead to any spectacular results and the proposed rules were not fully consistent in the cases studied.

13.6.5 The Model For Which The Magnetic Body Of Water Is Involved

The improved approach to protein folding starts from the general vision about magnetic body containing dark matter as a controller of visible matter in living system. The protein and its magnetic body would be regarded as a living system in itself.

1. Magnetic body must have large number of flux tube contacts to the visible matter. An excellent candidate for the magnetic body is that assignable with water and having flux tube connections to DNA and both hydrophilic and hydrophobic amino-acids. The magnetic body could control and at least fasten the self-organization process leading to the folding pattern which - by applying standard argument - would otherwise take astronomical time otherwise. The two-step attractive connections between all hydrophilic amino-acids would be possible via the magnetic body of water. The non-hydrophilic amino-acids not in direct contact with water are known to be more like passive structural stuff responsible for a fixed structure but not so relevant for the functioning of the bio-molecule. Hydrophily and hydrophoby would reflect the dependence of interaction energy on the value of Planck constant associated with the flux tube mediating the interaction.

2. This picture implies a straightforward modification of the earlier model. The simplest model would minimize a potential function V expressible as a sum $V = V_1 + V_2 + V_3$ of three terms. V_1 would be sum of the values of a universal two-particle potential function $V_{phi,phi}(r)$ for arguments $r_{ij} = |r_i - r_j|$ varying over all hydrophilic amino-acid pairs and giving rise to an attractive force. V_2 would be a sum of a universal two-particle potential function $V_{pho,pho}(r)$ for arguments $r_{ij} = |r_i - r_j|$ varying over all hydrophobic amino-acid pairs. V_3 would be would

	A and D	*A or D*	*no flux tubes*
$X_{12} \times X_{12}$	$T \times T$	$T \times t$	$t \times t$
$X_{34} \times X_{34}$	$U \times U$	$U \times V$	$V \times V$
$X_{12} \times X_{34}$	$X_{12} \times W$	$T \times X$	$t \times X$

Table 13.1: General structure of pairings for $Y = Z_c$ and $Y = Z$ options. *A and D* means that both amino-acids can act as acceptors and donors. *A or D* that only acceptor or donor property is possible.

    be sum of the values of a universal potential function $V_{phi,pho}(r)$ for arguments $r_{ij} = |r_i - r_j|$ varying over all pairs of hydrophilic and hydrophobic amino-acids. This potential function would induce a repulsive force. Besides this a constraint force due to the fact that amino-acids form a sequence would be present.

3. The resultant of the forces along lines connecting amino-acids would be parallel to the amino-acid sequence in the mechanical equilibrium. Hydrogen bonds and other bonds are indeed formed between neighboring hydrophilic amino-acids and the contraction of the flux tubes connecting the amino-acids in question to the magnetic body of water could be the mechanism. The model seems to be consistent with the basic qualitative facts about folding. The quantitative testing of the model would require determination of the conformations minimizing the potential function subject to the constraint provided by amino-acid sequence. Here of course the freedom to choose the three functions provides a considerable flexibility and symmetry arguments might allow to pose conditions on the form of these functions.

4. One could also include to the potential function describing a direct interaction with water molecules depending on parameters like pH affecting the folding pattern. The resultant for a given amino-acid would be sum of forces directed from a hydrophilic amino-acids to neighboring water molecules. It is not clear whether the normal component of this force could be compensated by the induced forces between amino-acids in a typical equilibrium configuration and the formation of hydrogen bonds involving the contraction of the flux tube could be the manner to achieve this.

Could one regard amino-acids and DNAs of given type as analog of species?

An interesting idea raised by the work with the model for protein folding is that the magnetic bodies amino-acids or DNA codon of a given type could behave like single phase on their respective page of the book so that the mutual interactions of their magnetic bodies could affect considerably the behavior of this phase to first order although amino-acids themselves are at different positions and one might expect only small correlations between their motions. Whether the dynamics of amino-acids of given type in protein folding are strongly correlated could be tested.

    In certain sense one could speak of single species formed by amino-acids of given type and folding as long range interaction could be seen as an outcome of self-organizing interaction between members of various species and between species themselves plus short range constraints due to the fact that amino-acids form a sequence. The question applies to DNA and RNA codons and also to larger units such as genes formed to which one could assign their own page of the book. Water would represent the page to which all DNAs can send flux tubes. Even the notion of biological species could involve common dark space-time sheet(s) where the magnetic bodies of the members of species are and interact making the members of species to behave like single coherent unit.

13.6.6   Appendix: Tables related to the model of protein folding

Table 13.6 represents the results of the test when flux tube from $Y(n)$ to $Z(n+k)$ or from $Z(n)$ to $Y(n+k)$ is prerequisite for hydrogen bond.

$A \times D$	$no\ flux\ tubes$
$X_{12} \times X_{12}$	$X_{12} \times t_1$
$X_{34} \times X_{34}$	$X_{34} \times V$
$X_{12} \times X_{34}$	$X_{12} \times W$
$X_{34} \times X_{12}$	$X_{34} \times t_2$

Table 13.2: General structure of pairings for $Y = Z_c$ and $Y = Z$ options. A and D refer to acceptor $(O =)$ and donor $N - H$ respectively. Only non-allowed hydrogen bonded pairs are listed.

protein	L(3)	L(4)	L(5)	L(6)
asparagin synthethase				
$Y = Z_c$	11.8	15.0	12.2	13.2
$Y = Z$	55.0	47.1	47.1	47.1
xylose isomerase				
$Y = Z_c$	10.2	9.7	12.4	11.3
$Y = Z$	24.8	24.8	16.5	26.4
hydrolase				
$Y = Z_c$	13.8	18.4	16.6	12.8
$Y = Z$	55.3	20.8	33.2	27.7
glutathione s-transferase				
$Y = Z_c$	12.4	12.4	13.1	15.0
$Y = Z$	35.0	35.0	26.3	30.0
BamHI				
$Y = Z_c$	9.7	8.5	10.7	10.7
$Y = Z$	30.4	23.7	30.4	35.5

Table 13.3: The average number $L(k)$ of amino-acids in the portion of amino-acid sequence satisfying the conditions making possible $(n, n + k)$ hydrogen bonding for $k = 3, 4, 5, 6$ for $Y = Z_c$ and $Y = Z$ option in the case that flux tube can connect $Y(n)$ to $Z(n + k)$ or $Z(n)$ to $Y(n + k)$.

alpha helix	$N(Y = Z)$	$N(Y = Z_c)$
xylose isomerase		
[74, 93]	(2, 1, 0, 1)(met-lys)	(1, 5, 1, 0)
[111, 129]	(0, 1, 0, 1)(asn-asp)	(2, 1, 0, 0)
[159, 179]	(0, 1, 0, 0)(asp-tyr)	(5, 4, 1, 3)
[201, 223]	(1, 1, 1, 2)(met-tyr)	(4, 3, 4, 3)
[245, 255]	(2, 0, 0, 0)	(0, 1, 1, 0)
[278, 287]	(0, 1, 0, 0)(his-tyr)	(0, 0, 0, 1)
[314, 327]	(0, 0, 2, 1)	(2, 0, 1, 1)
[349, 374]	(0, 0, 4, 0)	(3, 4, 1, 2)
[376, 386]	(1, 0, 0, 0)	(2, 1, 1, 1)
[393, 399]	(0, 0, 0, 0)	(0, 0, 0, 1)
[404, 414]	(0, 0, 0, 0)	(1, 1, 1, 1)
[424, 435]	(0, 0, 1, 0)	(2, 1, 2, 0)
hydrolase		
[39, 50]	(0, 0, 0, 1)	(2, 1, 2, 1)
[60, 79]	(0, 1, 0, 0)(asn-asp)	(2, 2, 3, 1)
[93, 113]	(1, 1, 0, 1)(val-gly)	(3, 0, 2, 1)
[115, 121]	(1, 0, 0, 0)	(0, 0, 0, 0)
[126, 134]	(0, 0, 1, 0)	(1, 0, 0, 0)
[143, 155]	(0, 0, 0, 0)	(0, 0, 0, 1)
glutathione s-transferase		
[12, 24]	(0, 0, 1, 0)	(0, 0, 0, 0)
[65, 76]	(0, 0, 1, 0)	(0, 1, 0, 0)
[83, 108]	(3, 2, 3, 1)(met-glu-asp)	(0, 0, 1, 0)
[111, 134]	(0, 0, 1, 2)	(3, 1, 4, 2)
[150, 166]	(1, 1, 2, 0)(asp-leu)	(1, 1, 1, 0)
[174, 184]	(0, 0, 0, 0)	(0, 0, 0, 1)
[187, 194]	(0, 0, 0, 0)	(0, 0, 0, 0)
BamHI		
[10, 18]	(0, 0, 0, 0)	(0, 0, 0, 0)
[20, 34]	(0, 0, 0, 0)	(0, 1, 1, 1)
[58, 72]	(1, 0, 1, 1)	(0, 0, 0, 0)
[79, 84]	(0, 0, 0, 0)	(0, 0, 0, 0)
[117, 132]	(0, 0, 0, 0)	(0, 0, 0, 0)
[146, 150]	(1, 1, 0, 0)	(0, 0, 0, 0)
[159, 169]	(0, 0, 0, 0)	(0, 0, 0, 0)
[200, 205]	(0, 0, 0, 0)	(0, 0, 0, 0)

Table 13.4: The test for alpha helices of four enzymes. The first column gives the range of amino-acids defining the alpha helix in question. The vectors in second and third column give the numbers of failures for $k = 3, 4, 5, 6$ for $(n, n + k)$ helix ($k = 4$ is the most interesting value). The amino-acid-pairs for which the hydrogen bond does not exist for $Y = Z$ option are given.

beta sheet	$N(Y = Z)$	$N(Y = Z_c)$
asparagin synthethase		
[113, 122]	0	2
[233, 240]	0	0
[245, 255]	0	0
[290, 297]	0	3
xylose isomerase		
[43, 47]	0	0
[96, 100]	0	2
[134, 140]	0	1
[262, 267]	0	0
[291, 295]	0	0
hydrolase		
[14, 19]	0	0
[25, 28]	0	0
glutathione s-transferase		
[3, 7]	0	0
[28, 32]	0	3
[54, 58]	0	0
[60, 63]	0	0
BamHI		
[2, 8]	0	0
[46, 48]	0	0
[70, 72]	0	0
[95, 100]	0	0
[105, 112]	0	0
[138, 144]	0	0
[174, 180]	0	0
[183, 185]	0	1

Table 13.5: The test for beta sheets of four enzymes. The first column gives the range of amino-acids defining the beta sheet in question. The vectors in second and third column give the numbers of failures for $k = 1$ for $(n, n + 1)$ helix.

protein	L(3)	L(4)	L(5)	L(6)
asparagin synthethase				
$Y = Z$	4.5	4.9	4.6	4.9
$Y = Z_c$	4.2	4.7	5.3	4.6
xylose isomerase				
$Y = Z$	3.7	4.3	3.5	3.9
$Y = Z_c$	4.0	3.0	4.1	3.8
hydrolase				
$Y = Z$	5.7	5.1	4.2	4.3
$Y = Z_c$	4.6	5.0	6.1	5.1
glutathione s-transferase				
$Y = Z$	5.1	5.8	4.6	4.0
$Y = Z_c$	4.5	3.6	4.0	4.7
BamHI				
$Y = Z$	11.3	16.8	15.6	12.9
$Y = Z_c$	16.8	10.4	12.1	12.9

Table 13.6: The average number $L(k)$ of amino-acids in the portion of amino-acid sequence satisfying the conditions making possible $(n, n + k)$ hydrogen bonding for $k = 3, 4, 5, 6$ for $Y = Z_c$ and $Y = Z$ option in the case that flux tube can connect $Y(n)$ to $Z(n + k)$.

alpha helix	$N(Y = Z)$	$N(Y = Z_c)$
asparagin synthethase		
[7, 28]	(4, 4, 4, 2)	(6, 4, 3, 5)
[76, 84]	(1, 0, 1, 1)	(2, 2, 1, 1
[130, 155]	(5, 5, 4, 5)	(2, 2, 2, 1)
[170, 177]	(0, 0, 1, 1)	(1, 1, 1, 1)
[182, 194]	(1, 1, 1, 1)	(2, 2, 1, 1)
[256, 268]	(1, 3, 0, 3)	(3, 0, 3, 0)
[277, 284]	(0, 0, 0, 0)	(0, 0, 0, 0)
[297, 305]	(0, 0, 0, 0)	(1, 0, 0, 0)
[309, 314]	(0, 1, 0, 0)	(2, 0, 1, 0)
[320, 326]	(1, 1, 0, 0)	(0, 0, 0, 0)
xylose isomerase		
[74, 93]	(6, 1, 6, 4)	(2, 5, 4, 3)
[111, 129]	(3, 3, 4, 2)	(4, 4, 4, 3)
[159, 179]	(3, 4, 6, 3)	(4, 3, 1, 3)
[201, 223]	(3, 6, 5, 4)	(5, 7, 4, 4)
[245, 255]	(1, 1, 1, 1)	(0, 1, 0, 0)
[278, 287]	(2, 1, 1, 0)(his-tyr)	(0, 0, 0, 1)
[314, 327]	(1, 2, 3, 3)	(2, 3, 2, 2)
[349, 374]	(4, 3, 8, 6)	(5, 8, 1, 3)
[376, 386]	(4, 0, 2, 3)	(1, 4, 3, 0)
[393, 399]	(0, 0, 0, 0)	(1, 0, 0, 0)
[404, 414]	(1, 1, 2, 1)	(3, 3, 1, 1)
[424, 435]	(1, 2, 0, 2)	(3, 2, 3, 1)
hydrolase		
[39, 50]	(2, 3, 0, 2)	(2, 1, 3, 1)
[60, 79]	(4, 2, 2, 4)(asn-asp)	(4, 4, 5, 2)
[93, 113]	(2, 1, 4, 4)(val-gly)	(3, 2, 1, 1)
[115, 121]	(0, 1, 0, 0)	(0, 1, 0, 0)
[126, 134]	(0, 1, 1, 1)	(1, 0, 0, 0)
[143, 155]	(0, 1, 1, 1)	(1, 0, 1, 1)
glutathione s-transferase		
[12, 24]	(1, 4, 2, 4)	(5, 2, 3, 1)
[65, 76]	(3, 1, 1, 0)	(2, 1, 1, 1)
[83, 108]	(5, 3, 5, 5)	(5, 3, 3, 2)
[111, 134]	(4, 5, 5, 4)	(4, 5, 3, 3)
[150, 166]	(2, 2, 3, 0)(asp-leu)	(4, 3, 1, 3)
[174, 184]	(0, 0, 0, 0)	(1, 1, 1, 1)
[187, 194]	(1, 1, 0, 1)	(0, 2, 0, 1)
BamHI		
[10, 18]	(0, 0, 0, 0)	(0, 0, 0, 0)
[20, 34]	(4, 1, 1, 2)	(2, 5, 4, 2)
[58, 72]	(3, 1, 2, 4)	(3, 5, 4, 1)
[79, 84]	(0, 0, 0, 0)	(0, 0, 0, 0)
[117, 132]	(0, 0, 0, 0)	(0, 0, 0, 0)
[146, 150]	(1, 1, 0, 0)	(0, 0, 0, 0)
[159, 169]	(0, 0, 0, 0)	(0, 0, 0, 0)
[200, 205]	(0, 0, 0, 0)	(0, 0, 0, 0)

Table 13.7: The test for alpha helices of four enzymes in the case of $Y(n) = Z(n + k)$ option. The first column gives the range of amino-acids defining the alpha helix in question. The vectors in second and third column give the numbers of failures for $k = 3, 4, 5, 6$ for $(n, n + k)$ helix ($k = 4$ is the most interesting value).

beta sheet	$N(Y = Z)$	$N(Y = Z_c)$
asparagin synthethase		
[113, 122]	1	5
[233, 240]	3	0
[245, 255]	1	0
[290, 297]	0	1
xylose isomerase		
[43, 47]	0	1
[96, 100]	2	4
[134, 140]	2	0
[262, 267]	2	1
[291, 295]	0	1
hydrolase		
[14, 19]	1	2
[25, 28]	0	0
glutathione s-transferase		
[3, 7]	0	1
[28, 32]	1	3
[54, 58]	4	1
[60, 63]	0	0
BamHI		
[2, 8]	0	0
[46, 48]	0	0
[70, 72]	2	0
[95, 100]	0	0
[105, 112]	4	0
[138, 144]	0	0
[174, 180]	0	0
[183, 185]	1	2

Table 13.8: The test for beta strands of four enzymes for $Y(n) = Z(n + 1)$ option. The first column gives the range of amino-acids defining the beta sheet in question. The vectors in second and third column give the numbers of failures for $k = 1$ for $(n, n + 1)$ helix.

Chapter 14

Dance of the honeybee and new physics

14.1 Introduction

For more than two decades ago mathematician Barbara Shipman made rather surprising finding while working with her thesis [A7, A8]. The 2-D projections of certain curves in flag manifold $F = SU(3)/U(1) \times U(1)$ defined by the so called momentum map look like the waggle part of the dance of the honey bee (see http://tinyurl.com/c7pljpw). Shipman found [A6, A9, A5] that one could reproduce in this framework both waggle dance and circle dance (special case of waggle dance) and the transition between these occurring as the distance of the food source from the nest reduces below some critical distance of about 10-20 meters. Shipman introduced a parameter, which she called α, and found that the variation of α allows to integrate various forms of the honeybee dance to a bigger picture. Since $SU(3)$ is the gauge group of color interactions, this unexpected finding led Shipman to as whether there might be a profound connection between quantum physics at quark level and macroscopic physics at the level of honeybee dance.

The average colleague of course regards this kind of proposal as crackpottery: the argument is that there simply cannot be any interaction between degrees of freedom in so vastly different length scales. This argument actually resembles the argument of nuclear physicists against "cold fusion" and is based on the dogma of length scale reductionism. Personally I however found this finding fascinating and wrote about the interpretation of this finding in the framework of TGD and TGD inspired consciousness [K50, K44].

During more than two decades a lot of progress has taken place in TGD, in particular I have learned that flag manifold F has interpretation as twistor space of CP_2 and plays a fundamental role in twistor lift of TGD [K114, K49, L52, K19]. Hence, when Johan Frisch contacted and asked whether I could help him to get material about the work of Shipman, I got interested in honeybee dance and realized that the earlier picture could be made much more detailed. I am grateful for Jerry Decker for finding links and references to the work of Shipman from web.

It is appropriate to begin by summarizing the new elements of TGD relevant for the honeybee dance.

1. In TGD framework an entire hierarchy of scaled variants of QCD like physics is possible by p-adic length scale hypothesis stating that preferred p-adic length scales $L_p \propto \sqrt{p}$ correspond to primes $p \simeq 2^k$. This hypothesis was inspired by the success of p-adic mass calculations [K76, K64]. In particular, in biologically especially relevant length scale range from 10 nm (cell membrane thickness) to 2-5 μ (size of cell nucleus) as many as 4 candidates for scaled variants of QCDs could exist: they would correspond to Gaussian Mersennes $M_{G,k} = (1 + i)^k - 1$, $k = 151, 157, 163, 167$. The existence of so many Gaussian Mersennes in so narrow a length scale range is a number theoretical miracle. The interaction of honeybee could be with scaled up variant of QCD like physics and the quarks could have the size of cell nucleus!

2. The flag manifold $F = SU(3)/U(1) \times U(1)$ has an interpretation as the space for the choices

for the quantization axes of color quantum numbers (color hypercharge and isospin). Few years ago it turned out that F is the twistor space of CP_2 and possesses Kähler structure [K114, K19, L52]. As a matter of fact, S^4 and CP_2 are the only compact spaces with twistor space possessing Kähler structure. Also M^4 and E^4 - kind of non-compact variants of S^4 - allow twistor space with Kähler structure (M^4 in generalized sense). Hence the existence of twistor lift of TGD implies that TGD is completely unique.

TGD inspired theory of consciousness [K66] leads to a proposal concerning the identification of qualia [K50]. One can distinguish between non-geometric qualia - colors, tastes, and odours - and geometric qualia representing geometric information such as angles and distances. Flag manifold qualia would be universal "general purpose" geometric qualia representing geometric information. In the model for the honeybee dance the point of 6-D flag manifold F would represent positional information about the food source and waggle dance would represent this point of F as a dynamical pattern very much like the point of momentum space is represented as orbit in configuration space.

3. TGD predicts hierarchy of Planck constants $h_{eff}/h = n$ labelling the levels of a dark matter hierarchy identified as phases of ordinary matter residing at flux tubes of magnetic bodies (MBs) assignable to ordinary physical systems. In the adelic vision h n corresponds to the dimension of the extension of rationals defining particular adele in the hierarchy of adeles having interpretation in terms of an evolutionary hierarchy [L50] [L51]. The scaling of Planck constant by n means similar scaling of Compton lengths implying zooming up of the microscopic physics. These scaled up variants of particles at the MB of the living system play a crucial role in TGD inspired quantum biology, and even suggests new physics associated with the notion of valence bond highly relevant to metabolism [L46] (see `http://tinyurl.com/ycg94xpl`).

This background gives good motivations for looking whether Shipman's findings could make sense in TGD Universe. It however turned out difficult to find any material relating to Shipman's work in web and the popular articles do not tell the details. There are several questions to be answered.

What do momentum map and 2-dimensional projection really mean? What the curves studied by Shipman really are?

1. Momentum map μ is a standard notion and actually familiar for physics albeit being represented using totally different language. In the case of general Lie group G acting as symmetries of symplectic manifold M, μ maps the elements of g ($su(3)$ now) represented as vector fields of M or the images of corresponding one-parameter groups (flows) to the elements of the co-adjoint algebra g^* of g having Poisson structure. One-parameter groups associated with the elements of g are mapped to conserved Hamiltonians associated with them. Mathematician speaks of co-adjoint orbits as images of orbits in M.

2. Physicist would see the situation either at the level of configuration space ("q-space") or momentum space ("p-space"). Exponential map takes each element X of Cartan algebra $h \subset g$ to an image of corresponding one-parameter group by exponential map, the orbit of the flow defined by X.

Since M allows symplectic structure and G acts as symmetries, each orbit is characterized by conserved Hamiltonians associated with elements of g. Only the Hamiltonians assignable to h commute with respect to Poisson bracket.

The image of H in M is spanned by 1-parameter subgroups associated with H. In momentum space picture given orbit corresponds to single point in co-adjoint algebra g^* defined by the two conserved Hamiltonians defining the momentum of the particle.

3. The choices of H are labelled by flag manifold F and each point of F defines a 2-momentum in h^*. The projection of F to $h*$ defines so called momentum polytope, which is hexagon. This notion makes sense completely generally.

What could be the TGD counterpart of this general picture? Consider first the general dynamics.

1. In TGD framework the new element is that the 2-D image Y of $U(1) \times U(1) \subset SU(3)$ in CP_2 is further projected to the space-time surface $X^4 \subset M^4 \times CP_2$: one simply forms the intersection $X = Y \cap X^4$. X (as already Y) carries vanishing induced Kähler form being thus analogous to Lagrangian sub-manifold. X is also analogous to the so called Chladni surface at which electric field vanishes: the physical meaning of these surfaces is discussed in [L35].

   The dynamics of the twistor lift of Kähler action [K114, L52, K19] reducing to a 4-D generalization of a dynamics coupling geodesic motion of point particle to induced Kähler field (analogous to Maxwell field) would fix space-time surfaces and therefore also the surfaces X. This dynamics could be also seen as a generalization of Chladni mechanism. Asymptotic self-organization patterns indeed correspond to the vanishing of the induced Kähler force inside given space-time sheet. These space-time regions correspond to external particles entering CD in ZEO based view about scattering. At point-like limit the external particles would be geodesic lines and in interaction regions move under Kähler force.

2. In the general case the dimension $D(X)$ of X satisfies $D(X) \leq 2$. One can have $D(X) = 2$ if space-time surface carries vanishing induced Kähler form: these surfaces are special case of minimal surface extremals for the twistor lift of Kähler action [K19] [L33].

   There are also other kinds of preferred extremals. Cosmic string solutions are of form $X^2 \times S^2 \subset M^4 \times CP_2$, where X^2 is minimal surface - string world sheet and S^2 is geodesic sphere of CP_2. CP_2 has two non-equivalent geodesic spheres. The first one has vanishing induced Kähler form and second is homologically non-trivial (non-contractible) and carries Kähler magnetic flux.

   One has also more general preferred extremals $X^2 \times Y^2$, where Y^2 is complex sub-manifold of CP_2 obtained by replacing S^2 with a sphere with $g \geq 1$ handles. These flux tubes are infinitely thin but one can deform them in M^4 directions to get magnetic flux tubes of finite thickness, which are key players in TGD inspired quantum biology.

3. The proposal is that simple modifications of these extremals exist as preferred extremals. One can "kick" Y^2 in rotational rigid body motion in CP_2 such that there are separate rotations in temporal and spatial directions of X^2. The surface X would be 2-D projection of $U(1) \times U(1)$ to X^2. Symmetry breaking can occur and reduce the projection esentially to that for $U(1) \subset U(1) \times U(1)$, and one obtains a unique waggle run along flux tube. Note that this ansatz works also for the M^4 deformations of cosmic strings.

   Surfaces X at string world sheets X^2 or equal to them would thus serve as representations for the points of F.

   What about the details of the waggle dance?

1. Additional information such as waggling can be coded by the dynamics of the modified $X^2 \times Y^2$ with rotating Y^2 deformed in M^4 degrees of freedom. X has one time-like direction so that the two waggle runs must correspond to two distinct points of F related by a symmetry realized as a reflection with respect to the line connecting the hive to the food source (the two waggle runs give rise to a V shape with edges representing the horizontal projection of the line to the food source).

   The necessity of the crucial phase transition from waggle dance to circle dance (special case of waggle dance) follows actually without any assumption about the model for the proposed coding of position information about food source.

2. The temporal duration assignable to X defines naturally the duration of the waggle dance in turn coding for the distance of the food source and identifiable as TGD counterpart for the parameter α of Shipman.

3. Waggle run involves two important frequencies: vibration frequency f_v of wings and waggle frequency f_w: these frequencies could correspond to the two conserved Hamiltonians - essentially frequencies (f_1, f_2) associated with the waggle run.

In the sequel I will summarize some basic facts about honeybee dance, sum up what I understand from the work of Shipman, and discuss the TGD based model and compare it with Shipman's work. The TGD inspired model is inspired by the twistor lift of TGD giving special status for the twistor space of CP_2 as flag manifold $F = SU(3)/U(1) \times U(1)$, by the general vision provided by TGD about living matter, by the TGD based model for qualia, by the basic knowledge about honeybee dance - in particular the intriguing observation the two basic frequencies associated with dance correspond to cyclotron frequencies - , and by the interpretation of the findings of Shipman.

Before continuing it is appropriate to list references to Shipman's work. Work related to Toda lattices can be found at [A7, A8]. There are also articles in arXiv (see `http://tinyurl.com/y998f9v6`, `http://tinyurl.com/yapgjprt`, and `http://tinyurl.com/y7a47f39`). The work related to honeybee dance can be found in the articles [A9, A5].

14.2 Some empirical facts

The background for TGD based proposal concerning the dance of honeybee relies on some key empirical facts and the attempt to understand the intriguing findings of Barbara Shipman in TGD framework.

There are articles in ScienceDirect discussing waggle dance from the perspective of neuroscience (see `http://tinyurl.com/ycuhjybt`). For instance, "Dance Language" by Dyer and "Learning Theory and Behaviour" by Marco and Menzel are warmly recommended.

The beginning of the article of Dyer gives some idea about the importance of the decoding of waggle dance by Frisch.

> *Anyone who has watched bees dance for food, and is aware of the function of this behavior, cannot help but be amazed. Karl von Frisch's decoding of the dance language is certainly one of the great discoveries in modern biology. This is not only because of the inherent fascination that the dance holds for curious human observers. Even more important is the extent to which von Frisch's discovery laid the foundation for the study of deep questions about animal behavior. When we consider the role that the dance language has played in the study of vision, olfaction, audition, learning, circadian rhythms, decision making, social organization, and behavioral evolution, it is easy to see why von Frisch regarded the dance language as a 'magic well' of discovery. Furthermore, with advances in neuroscience, genomics, and evolutionary theory, it seems clear that the value of the dance as a model system will continue for many years to come.*

From this it is clear that waggle dance involves multi-sensory communications including vision, hearing, and olfaction. There are several questions to be answered. What information does the dance convey? How the dancer gathers this information? How the audience extracts this information from the dance? The basic puzzle is how an insect with so small cognitive capacity (no cortex nor limbic brain) is able to carry out this feat?

Swarm intelligence is proposed as an answer: this would not involve consciousness. I would be surprised if deep learning were not proposed as a solution. But is this enough? Should one consider bee as part of larger conscious entity - the hive - just like one regards single neuron as part of brain? And what about cognition: should one have genuine theory of consciousness describing also cognition: the formulation of TGD as adelic physics indeed provides a theory of cognition [L51] [L50].

14.2.1 Basic facts about the dance

The dance of the honeybee occurs at the vertical face of the honeycomb and codes the information about the distance and direction of the food source. Von Frisch discovered the choreographic syntax and interpretation of the dance and published the results of his work in his 1967 book *"Dance language and Orientation of Bees"* [J122].

The pattern of the dance is that of figure eight above certain critical distance to the food source and that of a circle below this distance.

1. The angle of the figure eight pattern with respect to the vertical codes the angle between the direction of the food source and the horizontal projection of Sun. For instance, when the food source is in the direction of Sun, figure eight pattern is vertical. The dancer waggles and produces buzzing sound during the first phase of the dance and then walks to the original position along the other circle of the figure eight. After that the dancer waggles again but now along the second circle of the figure eight so that the waggling phases of the dance form the pattern of a figure V in the middle of the figure 8. The buzzing sound produced by the wings of the dancer makes it possible for the audience to locate the dancer (dance occurs in darkness). The opening angle of the figure V codes the distance to the food source for distances above some critical distance.

2. Below the critical distance the pattern changes to a circle. Now the waggling parts of the dance correspond to two disjoint straight line portions located at the opposite sides of the hexagon.

Besides waggle dance and circle dance as special case of waggle dance there are also other forms of honeybee dance such as tremble dance and grooming dance.

One can find summary about more quantitative empirical facts related to the waggle dance in Wikipedia (see `http://tinyurl.com/c7pljpw`). The following represents some facts relevant to the updated TGD inspired model are listed.

1. Waggle dance involves 100 or more circuits. The duration of the straight portion, waggle run, depends on distance: according to Wikipedia 1 second corresponds to 1 km. This might make sense at long enough distances but for short distances in the range 10-20 m this would mean millisecond time scale and this cannot make sense.

2. The dance language codes positional information about the food source (this need not be the only information: also information about the quality of the nectar might be represented). The direction of the food source relative to Sun is coded to the direction of relative to the direction of gravity (vertical direction). The polar angle θ_S with respect to the direction of Sun is mapped to polar angle $\theta_{gr} = \theta_S$ with respect to the vertical direction defined by gravitational force. The atzimutal angle ϕ with respect to the projection of the solar direction to the horizontal plane is represented as such.

   The distance d of the food source is coded to the duration, call it T - of the waggle period and also to the number of wagtail movements during single waggle run (this is trivially true if the wagtail movements occur with same frequency f_w always). Also the vibration frequency f_v of wings correlates with d. One has $f_w \simeq 13$ Hz and $f_v \in [200, 300]$ Hz.

   Remark: These frequencies are not too far from cyclotron frequencies $f(Ca^{2+}) = 15$ Hz and $f(p) = 300$ Hz in endogenous magnetic field $B_{end} = 0.2$ Gauss explaining the quantal effects of ELF radiation on vertebrate brain [J28] [K89, K90].

3. What is remarkable that the orientation information - that is the values of θ and ϕ - is automatically updated to take into account the motion of the Sun. In brain as a computer paradigm this would require quite impressive computation taking into account the size of the brain of honeybee (no cortex and no limbic brain). Even humans are unable to perform this feat. Deep learning paradigm might help but personally I remain skeptic.

14.2.2 How forager bee could collect the position information?

Honeybee dance mediates information about both the direction and distance of the food source. In neuroscience approach identifying brain as a computer this information would be stored by computation. The proposal is that the foraging bee utilizes solar compass. The information about the direction in the plane of Earth would be stored by using the information extracted from the polarization of the sunlight. The cloud free regions can provide this information even in cloudy day.

It has been proposed that the information about the distance of food source is coded by the net motion of the visual features of environment along retina during the flight. Experimentation

has shown that it is the projected distance to the food source (rather than absolute distance) which is coded in this manner.

During flight bee develops positive electromagnetic charge, call it Q, to its abdomen. The charge is due to moving and rubbing together of the body parts. Also Q serves as a measure for the distance of the food source (see http://tinyurl.com/y8vcqc7n and http://tinyurl.com/ycn32wrk).

Interestingly, the pollen in flowers is negatively charged relative to environment and sticks to positively charged bees. The electric field of flow changes for 100 seconds after the visit of bee to prevent from futile visits. Bees also detect the electric field created by flower possessing negative charge relative to environment. Bees also detect electric oscillations.

14.2.3 Communications in other sensory modalities

Dance language is not purely visual. There are also communications in sensory modalities other than vision. Dancing bee produces and releases hydrocarbons: two alkanes, tricosane and penta-cosane, and two alkenes, (Z)-9-tricosene and (Z)-9-pentacosene, onto their abdomens and into the air. This makes possible communication by olfaction.

Also acoustic and electromagnetic communications are involved.

1. During dance sounds with frequencies f_v in the range 250-300 Hz are emitted from the vibrations of the wings. Flight sounds are in the same frequency range. It is reported (see http://tinyurl.com/y8qklrhx) that there is a preferred value of f_v around 265 Hz. Honeybees also prefer rhythmic sounds. These preferences allow to detect the sounds produced by honeybee dance in dark and noisy environment.

2. The value of f_v correlates with the distance of the food source decreasing with the distance (see http://tinyurl.com/ya4kq8b8). In the example discussed in the article f_v decreases from 315 Hz to 207 Hz at interval 50-1600 m. Also the duration of the wag run and the number of wagtail movements during the run increase with the distance.

   This vibration mediates auditory information. Acoustic oscillations can be however transformed to electromagnetic vibrations in the body of honeybee since living systems are piezo electrets. The antennae of bees are sensitive to em radiation at ELF frequencies.

3. The frequency f_w of lateral swinging of the body of dancer is reported to be 13 Hz (see http://tinyurl.com/ycsmlxt7). This frequency is below the consciously audible range in the case of humans but also now the transformation to electromagnetic oscillations is possible. During waggle run electric fields are emitted and a natural expectation is that the frequencies f_v and f_w define important electromagnetic frequencies.

What is intriguing is that f_w is in EEG range. As already observed, f_v and f_w could correspond to cyclotron frequencies of proton and Ca^{2+} in a magnetic field near to the endogenous magnetic field $B_{end} = .2$ Gauss needed to explain the quantal effects of ELF em fields in vertebrate brain.

Could radiation with frequencies in EEG range be important also in beehive? For years ago I asked the crazy question whether beehive could have the analog of EEG communicating information from beehive to its MB and making possible the control of beehive by MB using cyclotron radiation. The condition that cyclotron frequencies for MB are identical with some relevant frequencies of biological body is essential for resonance making possible communication and control.

14.3 The findings of Shipman

A popular article describing the findings of Barbara Shipman [A6, A9, A5] related to honeybee dance can be found at web (see http://tinyurl.com/96kzbw). These are however difficult to find. There are also articles about Toda lattices [A7, A8], which she studied in her thesis (see http://tinyurl.com/yde7h6q4).

The basic notions used by Shipman relate to the theory of symplectic manifolds M with symmetry group G. The notion of flag manifold is in an essential role. Moment(um) map to the co-adjoint g^* of the Lie algebra g having symplectic structure is involved. Also projections to the Cartan algebra $h \subset g$ and its image in M and to the co-adjoint h^* of the Cartan algebra of G are involved. These notions are standard.

What about the particle dynamics having curves as orbits? This question one cannot be answered firmly without access to the work of Shipman but I failed to find the work of Shipman in web anymore. The natural guess is however that the orbits correspond to actions inf M of one-parameter subgroups of G parameterized by g, which for symmetric spaces such as CP_2 correspond to geodesic lines. The subset of M spanned by the orbits assignable to the elements of $h \subset g$ is therefore a natural object.

Shipman studies in her thesis "$\widehat{\text{C}}$onvex polytopes and duality in the geometry of the full Kostant-Toda lattice") (see `http://tinyurl.com/yde7h6q4`) the dynamics of Toda lattices. These systems are completely integrable systems and Shipman uses generalized flag manifolds for this purpose. The groups involved are non-compact and have non-trivial Borel sub-groups (consisting of matrices with vanishing lower diagonal). I have briefly summarized the ideas related to Toda lattice in [K50].

It however seems that in the applications to honeybee dance one can study $SU(3)$, which is compact. For $SU(3)$ the Borel sub-group would formally reduce to $U(1) \times U(1)$ consisting of diagonal matrices.

Momentum map seems to be very general and allows very general dynamics. What is needed is that one can assign to each point of the orbit values of Hamiltonians $H_i = \mu(X_i)$ defined as contractions of vector fields X^i with the 1-form μ. The Hamiltonians of Cartan algebra commute with respect to Poisson bracket and therefore it is natural to consider the orbits for which these Hamiltonians are constant in Hamiltonian dynamics having G as symmetries. It would however seem that co-adjoint orbit (it would not reduce to a point for non-Hamiltonian dynamics) and its Cartan projection are always well-defined: even when the dynamics itself is not Hamiltonian and Hamiltonians are not conserved.

14.3.1   Dance of the honeybee

The following piece of text is summary of Shipman's findings that I wrote as I proposed g the TGD inspired model for honeybee dance in [K50]. It must be emphasized that the model to be discussed differs from this model introduced for more than twenty years ago. I cannot guarantee that Shipman would agree with all what I claim.

What Barbara Shipman found [A6] was that the images of certain curves of 6-dimensional flag manifold under the so called momentum map reproduce the dancing pattern of the honeybee if the six initial values determining the curve are chosen suitably. Only two of these parameters code the information about the food source. The article about the model of honeybee dance is not published yet but on the basis of short abstract [A6] it seems that the curves in question are solution curves associated with a completely integrable system known as a full Kostant-Toda lattice studied by Barbara Shipman [A7, A8].

The solutions of the $2(n-1)$ equations of motion associated with this model can be mapped to the solutions of certain completely integrable Hamiltonian system in the flag manifold $F_n = SL(n,C)/B$, where $SL(n,C)$ is the space of complex matrices with unit determinant and B is the space of upper triangular matrices with unit determinant. F_n is in turn isomorphic with $SU(n)/U(1)^{n-1}$ and this implies a connection with the quantum measurement theory of color charges in $n = 3$ case.

The dance of honeybee should somehow map the some curve of the flag manifold to a planar curve representing the dancing pattern. $SU(n)$ acts as Hamiltonian transformations of the flag manifold but not as symmetries of Kostant-Toda lattice (see `http://tinyurl.com/ybds7us2`): in particular, the Cartan algebra generators define Hamiltonians $H_I(x)$ and $H_Y(x)$ in F_3. The so called momentum map associating to the point x of the flag manifold F_3 the point $(H_I(x), H_Y(x))$ characterizing the values of the isospin and hypercharge Hamiltonians at the point x. The image of F_3 under this map is hexagonal region of plane and the image of Kostant-Toda orbit under this map is identified as the dancing pattern of the honeybee. It is obvious that $SU(3)$ cannot act as

symmetries of the Kostant-Toda system since in this case Hamiltonians would be constant along the solution curves and momentum map would map every orbit to single point.

To summarize the result concisely:

1. If the orbit of 3-surface in the flag manifold is characterized by Hamiltonian equations related to the so called Kostant-Toda lattice, which is a completely integrable system,

2. if the hexagonal planar region defined by the image of the momentum map corresponds to the "dance floor" and

3. if the orbit of the bee corresponds to the image of the orbit of flag manifold under the momentum momentum map,

one can understand the basic aspects of the waggle dance.

One can indeed understand the dance of honeybee as a representation for the information content of thought of the honeybee. What forces one to take the model seriously is that it reproduces also the dependence of the dancing pattern on bee community and predicts correctly the spectacular change of the V shaped dancing pattern to a union two disjoint lines on the opposite boundaries of the hexagon like region.

Remark: The recent TGD inspired model to be discussed deviates from this picture since the intersection X of Shipman's projection with space-time surface defines the parquette for $D(X) = 2$ and also the dance for $D(X) = 1$.

14.3.2 Basic mathematical notions

It is appropriate to introduce the basic mathematical notions used by Shipman although the TGD based model is formulated without using these notions explicitly: the dance parquette is identified as the surface $X \subset X^4$ defined as the intersection of X^4 with the orbit of $U(1) \times U(1)$ in CP_2. For $D(X) = 1$ dance parquette reduces to dance pattern. For given orbit $U(1) \times U(1)$ the Hamiltonians associated with $u(1) \times u(1)$ Lie-algebra generators are constant.

1. The definition of the moment(um) map can be found from Wikipedia. One considers manifold M with symplectic structure and allowing group G as isometries. Any element of Lie-algebra g of G can be represented as a vector field X of M giving rise to orbits by exponential map. If X is symplectic transformation, the one parameter group associated with X is represented as orbit in M obeying Hamiltonian dynamics defined by the conserved Hamiltonian $H(X)$ assignable to X.

   At any point of M can map $X(x)$ to the dual g^* of g (co-adjoint of g) by contracting it with symplectic form J defining the symplectic structure. Momentum map gives just the Hamiltonian $H(X)$ associated with X. One starts from the formula

$$d\langle \mu, X \rangle = dH(X)$$

   for the contraction between 1-form μ and vector field X. Clearly, the Hamiltonians are defined only modulo additive constant. Along the orbit of the flow defined by X $H(X)$ is constant since one has Hamiltonian flow

$$\frac{dY}{dt} = \{H, Y\}$$

   applied to $Y = X$. Also the Hamiltonians associated with Lie-algebra generators commuting with X are constant along the orbits of X.

   One can define momentum map as one-form μ by requiring that the value of μ at point x of M for any X equals to Hamiltonian $H(X)$ at this point:

$$H(X(x)) = \langle \mu(x), X(x) \rangle \ .$$

Since the number of components of μ is the dimension $D(M)$ of M and g is $D(g)$-dimensional, this gives $D(M)$ equations for $D(N) > D(M)$ variables so that solutions exist. The condition that the Poisson brackets of Hamiltonians represent the Lie-algebra gives additional conditions allowing to fix μ.

2. Momentum map allows to assign to the orbits of the dynamical system obeying Hamiltonian dynamics conserved Hamiltonians and for completely integrable systems such as Toda lattice these conserved Hamiltonian fix the solution completely.

3. The Cartan sub-algebra h of g determines maximal number of commuting conserved quantities quantum mechanically and one can assign to the image of the classical system in g^* its projection to h^*. In TGD framework one can however argue that this does not provide an interesting representation of the waggle dance since a stationary position of the bee at dancing parquette would code for the position information.

   Rather, it would seem that the dual of this representation in which point of h^* determines the direction and magnitude of the momentum/velocity of the bee is more appropriate. One can also indeed h as a union of orbits of generators of h in M. Waggle run would correspond to one particular point of h. The Hamiltonians associated with vector fields of h would be constant at this surface.

4. The projection of flag manifold to the image of h in flag manifold $F = SU(3)/U(1) \times U(1)$ or any manifold M, say CP_2 with symplectic $SU(3)$ action would determine the 2-D dance parquette for $G = SU(3)$. At these 2-surfaces orbits would be parameterized by constant values of Hamiltonians defining color hypercharge and isospin. The choices of the subgroup $U(1) \times U(1)$ are parameterized by F and at each surface. As already noticed, one must consider the intersection of this set with space-time surface in TGD framework.

   One could say that the points of F representing the choices of quantization axes for color quantum numbers are represented by 2-D Lagrangian surface in CP_2 in TGD framework. This would realize quantum classical correspondence realizing the quantization axis as a dynamical pattern. As noticed, the projection to space-time surface need not be 2-D.

5. The projection map of $F = G/H$ to h^* defines so called momentum polytope having dimension of h (see `http://tinyurl.com/ycxddqz5`). In the case of $SU(3)$ polytope is 2-D hexagon. The fact that beehive has the structure of hexagonal lattice is taken by Shipman as an accident but one can ask whether this is really so.

14.4   TGD based model

The purpose of honeybee dance is to represent symbolically a behavioral pattern leading to a desired goal, a kind of a program. In ZEO behavioral patterns are fundamental whereas time=constant snapshots of dynamics are fundamental in standard positive energy ontology (PEO). ZEO is extremely restrictive: the preferred extremals of the action principle satisfy infinite number of additional gauge conditions reducing the effective number of space-time dimensions to 2 corresponding to the strong form of holography.

Number theoretic approach [L51, L50] forces even stronger form of holography: in which finite measurement resolution is a key aspect of dynamics reduces the locus of initial values to a set of discrete space-time points providing a cognitive representation for the system at space-time level [L45]. This picture conforms with the computationalistic idea that that finite number of numbers fixes the time evolution as an analog of computer program [L42].

The idea that forager bee would perform complex neuronal computations to store the data about the path to the food source looks to me somewhat questionable. At least these computations involved cannot be conscious. AI enthusiast would propose deep learning as a formation of associations leading to the miraculous ability of the bee to remember the path and represent it by dance pattern. This option looks more promising.

To me a more plausible view to consider is that the positional information is stored automatically to the MB of honeybee. This brings in the radical possibility that the forager bee actually generates temporary flux tube connections with the food source and has a permanent contact with

Sun and Earth via gravitational flux tubes. This would store the information to the MB of the bee and the updating would be automatic.

14.4.1 Some ideas of TGD and TGD inspired neuroscience and quantum biology

One should be able to model honeybee dance without introducing any adhoc assumptions. In particular, the dance itself should emerge at space-time level from the fundamental dynamics of TGD. Central notions are ZEO and magnetic body (MB) carrying dark matter as $h_{eff} = n \times h$ phases of ordinary matter. This hierarchy has first principle description in terms of adelic physics [L51, L50].

Zero energy ontology

TGD inspired theory of consciousness and quantum biology rely on few key ideas and notions. Zero energy ontology (ZEO) is of them. ZEO leads to an extension of quantum measurement theory to a theory of consciousness [L53]. The notion of causal diamond (CD) plays a key role in ZEO. ZEO implies that time=constant snapshots as counterparts of physical states are replaced by preferred time evolutions as 3-surfaces (analogs of Bohr orbits) connecting the 3-surfaces at the opposite light-like boundaries of CD analogous. Zero energy states states can be regarded as events with initial and final states at opposite boundaries of CD and classically represented as 3-surfaces.

Field equations in the twistor lift of TGD [K114, L52, K19] can be regarded as a generalization of the dynamics of geodesic motion coupled to Kähler force obtained by replacing 1-D curve with 4-D orbit X^4 of 3-surface. The preferred extremals can be divided to two kinds of regions. Regions of first kind represent external particles for which Kähler 4-force vanishes and which are minimal surfaces as analogs of light-like geodesics. Regions of second kind are interaction regions inside CDs where the Kähler 4-force is non-vanishing. Following biologists and neuroscientists one could speak about a generalization of the notion of behavioral pattern or biological function. Computer scientist would talk about programs.

In ZEO the act of free will would be analogous to a replacement of a deterministic program with a new one [L42]. ZEO is actually forced by the acceptance of the fact that we have free will, which must be consistent with the determinism of field equations. At quantum level, classical program as preferred extremal is replaced with a quantum superposition of classical programs, which in some resolution cannot be distinguished from each other.

The notion of magnetic body

The basic distinction between TGD and Maxwell's electrodynamics and gauge theories is that in TGD Universe any system has a field identity as separate space-time sheets, topological field quanta. They correspond to magnetic flux sheets or tubes and also to electric field has topological quanta. This follows from the notion of the induced gauge field. In Maxwell's theory fields of different systems interfere, in TGD they correspond to separate space-time sheets but particle experiences the sum of the forces caused by them since it touches these space-time sheets.

This modification forces the replacement

$organism + environment \rightarrow MB + organism + environment.$

MB receives sensory input from biological body (BB) and controls it. Sensory input to MB can be in terms of generalized Josephson radiation from cell membrane acting as generalized Josephson junction and coding nerve pulse patterns to frequency modulations. The control by MB can be realized in terms of cyclotron radiation to DNA (accompanied by what I call dark DNA [L34]).

Hierarchy of Planck constants

The hierarchy $h_{eff} = n \times h$, $n = 1, 2, 3, ..$ of Planck constants gives rise to a hierarchy of dark matters. $h_{eff} = n \times h$ labels the onion like layers of MB. The size scale of give layer is by uncertainty principle of order of cyclotron wavelength $\lambda \propto m/eB$ and thus proportional to particle mass m. The value of Planck constant determines the hierarchy level: n can be identified as the dimension of the algebraic extension of rationals defining the adele [L51], and measures the complexity of the

algebraic extension associated with the dynamics at the basic level, and therefore serves as a kind of IQ. Evolution corresponds to a gradual and unavoidable increase of $h_{eff}/h = n$ in statistical sense.

1. At the atomic level the value of n seems to be $n = 6$ rather than $n = 1$ [L46, L39]. For valence bonds the value of n is already larger and increases along the rows of the periodic table being largest for the molecules containing atoms towards the right end of the period: biologically important atoms C, N, O, S, P are examples associated with valence bonds with large n.

2. For protons at hydrogen bonds the value of n is much higher than for electrons of valence bonds and the generation of hydrogen bonds could be seen as a crucial aspect of bio-chemistry. Metabolic energy is measured as the difference of the energy of bond for ordinary value of h_{eff} from the real one and one can say that metabolic energy provides for the system ability to increase its negentropy. Metabolic energy increases h_{eff} resources: this is why we must eat.

An important additional hypothesis generalizes the notion of gravitational Planck constant due to Nottale [E2].

1. The hypothesis [K37, K38, K39, K40, K83] states that at the flux tubes mediating gravitational interactions (propagation of gravitons) one has

$$\hbar_{eff} = n\hbar = \hbar_{gr} = \frac{GMm}{v_0} \quad ,$$

where M and m are the masses associated with the ends of the flux tube and $v_0 < c$ has dimensions of velocity. This formula holds true if Mm/v_0 exceeds Planck mass squared and implies that the coupling parameter GMm in perturbation series is replaced with $v_0/c < 1$ so that one achieves convergence.

2. For large values of M the value of h_{gr} can be very large, which means that long range gravitational interaction can give rise to systems with very high cognitive resources. This hypothesis generalizes also to other interactions in rather obvious manner and the phase transition increasing the value of h_{eff} leads to dark phase in which perturbation theory converges (the value of the coupling strength $\alpha \propto 1/\hbar_{eff}$ is reduced).

3. The value of M depends on the state of the network defined by the flux tubes mediating gravitational interaction. At the limit of ordinary quantum gravity M would be mass of elementary particle. There is however entire dynamical fractal hierarchy of gravitational flux tubes completely analogous to those postulated flux tube hierarchies in neural system and in endocrine system. For instance, the fountain effect of superfluidity could correspond to a situation involving large value of h_{gr}. In living matter the mass of large neuron is of order Planck mass and defines kind of critical mass in the sense that gravitational interaction between two large neurons could correspond to h_{gr}.

4. $h_{eff} = h_{gr}$ hypothesis implies that cyclotron energies do not depend on the mass m of the charged particle and are therefore universal. The proposal is that the energy scale of bio-photons, which is in visible and UV appropriate for molecular transitions, corresponds to the energies of dark cyclotron photons, which can transform to bio-photons [K20]. The spectrum of the values of "endogenous" magnetic field B_{end} with nominal value $B_{end} = .2$ Gauss would corresponds to the energy range of bio-photons. Cyclotron photons would play central role in the control of biological body by MB based on resonance mechanism. Also the communications from biological body to MB would involve resonance mechanism.

Flag manifold qualia

TGD inspired theory of consciousness leads to a proposal concerning the identification of qualia [K50]. The original proposal was based on standard ontology and the sensory qualia were identified in terms of changes of quantum numbers in state function reduction: the problem of the

interpretation is that the outcome of the reduction is random and qualia could be defined only in statistical sense.

The recent view is based on the vision about self as a generalized Zeno effect [L53]. In ZEO qualia would correspond to quantum numbers measured repeatedly during the Zeno period having also interpretation as so called weak measurement.

1. One can distinguish between non-geometric qualia like colors, tastes, and odours, and geometric qualia representing geometric information such as angles and distances. Flag manifold qualia would be universal geometric qualia. In the model for the honeybee dance [K50] the point of 6-D flag manifold F would represent positional information about the food source and waggle dance would represent a point f of F (or an orbit inside the 2-surface of CP_2 representing f) as a dynamical pattern.

2. F has symplectic structure and this encourages the question whether flag manifold qualia could be divided to position type qualia and momentum type qualia. The symplectic structure of F forces to ask whether only degrees of freedom which correspond to mutually commuting Hamiltonians are representable. If so then the representations of qualia at space-time level could correspond to 2-surfaces for which Hamiltonians assignable to $U(1) \times U(1)$ are constant. Motion in this plane dictated by the values of these Hamiltonians as momenta would provide the representation of the geometric qualia at the level of CP_2.

3. The natural proposal is that the surface $X \subset X^4$ obtained as intersection of space-time surface and the orbit of $U(1) \times U(1)$ in CP_2 and depending on the dimension $D(X)$ analogous to string world sheet, curve, or even point corresponds to a kind of dance parquettes or dance itself.

4. In the case of M^4 twistor lift forces to introduce the geometric variant of twistor space as $M^4 \times CP_2$ and also generalization of Kähler structure and symplectic structure. The counterpart of $U(1) \times U(1)$ consists of translations in time-like plane and the point of the twistor space correspond to a choice of time axis (energy quantization axis) and quantization axis of spin.

   In fact, octonionic approach to TGD reducing the dynamics of TGD to algebraic geometry forces to introduce preferred time axis and spatial axis: they correspond to octonionic real unit and preferred imaginary unit [L45]. The 6-D twistor space $M^4 \times S^2$ labelling the choice of these axes would code for geometric information, and also now one would have a representation in terms of the intersection of space-time surface with this plane.

These arguments suggest that flag manifold qualia are something very fundamental and gives support for the discovery of Shipman. Honeybee dance would provide also support for the coherence of long range classical color gauge fields predicted by TGD.

14.4.2 Waggle and vibration frequencies as clues

The basic vision is that MB uses biological body (BB) as a motor instrument and sensory receptor. Control and communication mechanisms are based on resonance mechanism requiring that the changes of energies for some transitions are same at the level of MB and BB: this givesvery powerful constraints on prebiotic scenarios and allows to understand why just certain molecules were chosen as bio-molecules [L47, L55]. Cyclotron frequencies are in a special role and one expects that the resonant frequencies at the level of biological body correspond to cyclotron frequencies. Large value of h_{eff} guarantees that low frequency quanta have energies about thermal energy and therefore effective.

The fundamental dynamics would be that of magnetic flux tubes. Bee could simply move along a flux tube carrying dark ions. A more ore detailed model will be discussed later. The orbits at the image Y of $U(1) \times U(1)$ in CP_2 are labelled by two momenta, essentially frequencies since angle variables are in question. Could the frequencies (f_1, f_2) have counterparts in honeybee dance? There are indeed two key frequencies involved: waggle frequency f_w and vibration frequency f_v for the wings of the bee: could the identification $(f_w, f_v) = (f_1, f_2)$ make sense?

Some of the cyclotron frequencies involved should correspond to f_w and f_v.

1. The vibration frequency f_v for the wings of the bee varies in the range 200-300 Hz roughly. For $B_{end} = .2$ Gauss, which explains Blackman's findings about the quantal effects of ELF radiation [J28], the cyclotron frequency of Ca^{2+} would be $f(Ca^{2+}) = 15$ Hz (or its multiple corresponding to higher cyclotron transitions).

   300 Hz would correspond to protons cyclotron frequency for B_{end}. For $f_c(p) = 200$ Hz the value of B would be $B = 2B_{end}/3$. f_v could correspond also to electromagnetic frequency since acoustic signals are transformed to electric signals in living matter, which consists of piezo electrets.

2. The observed waggle frequency f_w is around 13 Hz and suggests that B_{end} is scaled down by factor 13/15 in this case. This scaling down reduces f_v to 250 Hz. The preferred value of f_v is reported to be around 265 Hz (see `http://tinyurl.com/y8qklrhx`) .

3. The average value of f_v is reported to decrease with the distance from 315 Hz at 50 m to 207 Hz at 1600 m (see `http://tinyurl.com/ya4kq8b8`). Therefore also the value of B_{end} should decrease with the distance. Interestingly, the lower bound $f_v = 200$ Hz corresponds to lower bound $f_w = 10$ Hz in alpha band and in the case of humans defines the lowest frequencies correlating directly with conscious experience. Alpha band indeed dominates in the transition from awake state to sleep.

4. These observations support the view that f_w and f_v allow interpretation as cyclotron frequencies, and force to ask whether proton and Ca^{2+} cyclotron frequencies are in key role in the communications between the dancer and the audience. It is indeed known that the dancer generates electric oscillations and the bees can detect them by their antennae. Proton and Ca^{2+} are also in a key role in the function of cells and neurons.

One cannot avoid the question whether beehive could have EEG or at least alpha band. Bees should not have EEG if the usual neuroscience interpretation for EEG frequencies as being produced by cortex is correct but in TGD one cannot be certain about this.

14.4.3   What should one understand?

One can try to understand the basic topology of the dance by starting from the interpretation for the information coded by it. This does require introduction any specific model for how the information is represented.

1. Why the waggle pattern transforms from two parallel lines for large distances to V shape at shorter distances and finally to two disjoint pieces of circle dance? A possible answer is that the angle between the edge of V and its diagonal represents the angle between the direction of the food source and its projection in horizontal direction. For long distances the angle is small so that the lines are nearly parallel.

   For short distances the angle becomes large. At criticality the upper edge of V becomes vertical and the dancing pattern must change since other wise the direction to the source is interpreted to opposite from the real one. Waggle periods must be in a direction parallel to the direction of food sources to code for the direction of the food source. Waggle period becomes short since it codes for a short distance.

2. Why two waggle runs - left and right run - as mirror images of each other with respect to the diagonal of V are needed. If waggle direction is actually the direction along the surface of Earth to the food source, waggle run and its mirror images are necessary for coding the information about the diagonal of V defining the direction to the food source.

   Suppose that the position information about the source is represented by a point of F.

1. How the coordinates of the point of F characterizing choices of $U(1) \times U(1)$ code for the position information? The intersections X of the orbits of $U(1) \times U(1)$ in CP_2 with the space-time surface have in the generic case $D(X) \leq 2$ and should code the position information. X can (and must) have one time-like direction. For $D(X) = 1$ this gives just single waggle run. The temporal length T of X codes defining the duration of the waggle codes for the distance of the food source.

2. The parameter α introduced by Shipman correlates with distance and could code it. Since the duration of the waggle run correlates with the distance, a possible interpretation of α as temporal duration T assignable to X. Also the value of the charge Q generated during the flight and proportional to the duration of the flight is roughly proportional to the distance and thus T and α.

3. Waggle frequency f_w is additional dynamical parameter related to the motion of the dancer. According to Wikipedia the higher the value of f_w is, the more excited the bee is. This would suggests that f_w varies. Waggling and f_w would relate to the dynamics of space-time surface involved (flux tube perhaps) in M^4 degrees of freedom rather than to the rather simple dynamics of geodesic motion in CP_2. Oscillating string is what comes in mind as approximation to the dynamics of the flux tube.

4. Vibration frequency f_v for wings is a further additional parameter. Also f_v would to the dynamics of X if the flux tube controls the motion of the bee. Cyclotron frequency hypothesis implies that the ratio f_v/f_w of waggle frequency and vibration frequency is constant equal to the mass number of Ca divided by two $f_v/f_w = A/2 = 20$.

   If $(f_w, f_v) = (f_1, f_2)$ identification makes sense then also (f_w, f_v) would be coded by the point of F.

   Remark: Amusingly, the same number 20 appears in the model for life like properties of a simple system of plastic balls in Argon gas: now the ratio of atomic weight of Argon and proton ($A(Ar) = 20$) gives it [L47] (see `http://tinyurl.com/y8wexfqo`). An explanation for the decrease of the f_v and (possibly of f_w too) with the distance of the food source would be needed. Could the long distance to the food source imply that the dancer is less excited? This would require the decrease of the value of B_{end} to which f_w and f_v are proportional with distance. The value of B_{end} could correspond to the magnetic field at the flux tube.

5. It seems that one can understand what happens to the position information at the criticality. One should also understand how the change of the dancing pattern is represented at the level of F and X. Why the intersections of $U(1) \times U(1)$ with space-time surface get short? Is this simply due to the fact that the temporal length of X is determined directly by the length of the path to the source.

   How the angle between Sun and target could be updated automatically?

1. In neuroscience approach identifying brain as a computer this information would be stored by computation. Deep learning algorithms would be proposed by AI people. Standard physics mechanism for storing the information about the direction angles are proposed. Foraging bee would utilize solar compass. The information about directions in plane of Earth would be stored by using the information coming the polarization of the sunlight.

2. Automatic updating of the direction S of Sun and the direction L of the food source relative to it should be understood. This requires computation and learning in neuroscience approach. I do not know enough about deep learning to articulate precisely why I do not believe this option.

   A more radical option is that MB of bee stores this information into its own geometry? The proposal has been that MB explains the third person perspective of consciousness: this would explain also OBEs [K93, K110]. Could the MB provide a representation for the dynamics of the bee and its environment including the Sun? If MB contains flux tube S in the direction of Sun defining a pointer of sundial so to say, a temporary flux tube L in the direction of food source, and a temporary flux tube H along projection of L parallel to Earth, this is guaranteed and updating takes place automatically.

3. How the temporary flux tubes would generated? In TGD inspired theory of consciousness flux tubes serve as a correlate for attention. Dancer has directed its attention to the food source and has become connected bya flux tube it. Could this bond be preserved so that the bee would be connected by flux tubes to the target? To be precise, these temporary flux tubes would be actually by pairs of flux tubes generated as flux tube loops from bee and food

source reconnect. One could also imagine kind of miniature variant of this representation if this sounds too non-local.

4. The flux tubes S in the direction of Sun would be naturally gravitational flux tubes possibly carrying dark matter with $h_{eff} = h_{gr}$. The mass M appearing in h_{gr} could be some fraction of solar mass. The angle between L and H a would code the information needed to realize the V shape. Same would apply to the gravitational flux tubes E of Earth. Earlier work suggests that a fraction 10^{-4} of Earths mass of the gravitational flux of Earth is at dark flux tubes $h_{eff} = h_{gr}$.

   These flux tubes would provide a cognitive representation for the direction S of Sun, for the line L connecting the hive to the food source, and for the projection H of L along the surface of Earth. The MB of bee should have also gravitational flux tubes of Earth and since they are orthogonal to H: could these two kinds of gravitational flux tubes make possible the representation of H as edge of V? H and L would be behave like rigid body whereas S would be like a pointer of sundial.

5. Does the rotation of the reference direction from L to E mean rigid body rotation for the MB (and body) of the dancer? Do solar flux tubes become flux tubes inside the vertical flux tubes? If so, the first part of waggle run would take place along the flux tube to target along H turned by $\pi/2 - \theta$. The second part of waggle run would take place along its mirror image with respect to rotated L.

   Consider now the role of $h_{eff}/h = n$ having two widely different ranges of values.

1. The cyclotron energies of p and Ca^{2+} are extremely small for the ordinary value of Planck constant. This was one of the reasons motivating to the introduction of the hierarchy of Planck constants $h_{eff}/h = n$ [K46, K37, K38, K39, K40]. The hypothesis $h_{eff} = h_{gr}$ implies that the cyclotron energies do not depend on the mass m of the particle and are in the range of energies of bio-photons (visible and UV). Also the gravitational Compton lengths of particles are independent of m. Also this encourages the consideration of the possibility that the MB of bee has flux tubes carrying gravitational flux tubes from Sun. The values are roughly of the order of 10^{14} if EEG photons have energies in visible and UV.

   The directions of gravitational flux tubes to Sun and Earth define two preferred stationary directions. It seems natural to assign to them gravitational Planck constants $h_{E,gr}$ and $h_{S,gr}$.

2. Relatively small values of n are assignable to electrons of valence bonds and of aromatic cycles [L46]. $n < n_{max} = 100$ is a rough estimate. Thus they are much smaller than the values of $n = h_{gr}/h$ assignable to dark protons at magnetic flux tubes of say hydrogen bonds and assignable to gravitational fields. The model for valence bonds based on TGD predicts that n increases along the row of the periodic table and the molecules appearing as nutrients have the highest values of n associated with their valence bonds.

   $h_{eff}/h = n$ serves as a kind of measure for IQ of the system. More precisely, the recent interpretation is that n expresses the ability of the system to generate negentropy. I have proposed that chemical senses might detect the value of n. For instance, the higher the value of n, the more pleasant the odour. Aromatic compounds with aromatic cycles would have dark electrons at the flux tubes assignable to the cycles and therefore would have value of n larger than the usual.

   Could the average value $\langle n \rangle$ measure the quality of the nectar? Could the dancer communicate the value of $\langle n \rangle$. Could be more excited if the average value of n is large. This should be reflected in the value of f_w via the value of B_{end} if f_w really measures how excited the bee is.

14.4.4 Concrete model for the coding of the information about waggle dance at MB

Magnetic flux tubes forming part of MB serve as controllers of BB in TGD inspired quantum biology. This suggests that it could be possible to build a concrete model for the control of waggle dance in terms of magnetic flux tubes.

1. The simplest flux tubes are infinitely thin and thus their orbits have 2-D M^4 projection. I call them cosmic strings. They are space-time surface of form $X^4 = X^2 \times S^2 \subset M^4 \times CP_2$, where X^2 is minimal surface - string world sheet - and S^2 is geodesic sphere of CP_2. CP_2 has two non-equivalent geodesic spheres. The first one has vanishing induced Kähler form and second is homologically non-trivial (non-contractible) and carries Kähler magnetic flux.

2. One has also more general preferred extremals $X^2 \times Y^2$, where Y^2 is complex sub-manifold of CP_2 obtained by replacing S^2 with a sphere with $g \geq 0$ handles.

3. One can deform these extremals in M^4 directions to get magnetic flux tubes, which are key players in TGD inspired quantum biology.

All geodesic circles of $Y^2 = S^2$ give rise to X with $D(X) = 1$ but the space-time projection is space-like and corresponds to single point in X^2. How could one get time-like X as a projection of $U(1) \times U(1)$ orbits? The idea comes from the dynamics of rigid body generalized to that for the complex surface $Y^2 \subset CP_2$.

1. Think Y^2 as a rigid body in CP_2 and "kick" it into a rotational motion. This extremely simple motion might produce a preferred extremal. The idea can be illustrated for a geodesic circle S^1 of ordinary sphere. One can "kick" S^1 to a rotational motion around any axis defined by a line from origin to a point of S^2. This motion describes geodesic circle as the image of a Cartan group $SO(2) \subset SO(3)$.

2. For infinitely thin flux tubes the space-time is effectively the string world sheet $X^2 \subset M^4$. X should define surface at X^2. For a rotating Y^2 the orientation of Y^2 in CP_2 depends on the time coordinate t of of X^2. One would have a geodesic motion corresponding to $U(1) \subset U(1) \times U(1) \subset SU(3)$.

3. One can also imagine the dependence of the orientation of Y^2 on the space-like coordinate x of Y^2: there would be "rotation" also in the x direction! The orientation of rotating Y^2 would depend on two string coordinates. Given $(t, x) \in X^2$ would correspond to a point $(\Phi, \Psi) \in U(1) \times U(1)$ and string world sheet itself to $U(1) \times U(1) \in F$! String world sheet would represent flag manifold qualia.

4. This picture is not yet realistic enough. One must have magnetic flux tubes with M^4 projection, which is not infinitely thin. They are obtained for the deformations $X^2 \times S^2$ solutions in M^4 directions increasing the dimension of M^4-projection so that it is 4-D. $D(X) \geq 1$ is however needed to explain honeybee dance.

5. Also for the realistic flux tubes one obtains the rotation by allowing rotation in the additional two directions. A reasonable first guess is that the rotation is everywhere in fixed $U(1) \times U(1)$: this would correspond to a global choice of quantization axes for color quantum numbers.

   Can one identify unique string world sheet X^2 now? What I call fermionic string world sheets are fundamental in TGD. They connect the orbits of partonic 2-surfaces carrying fermion numbers at their ends are indeed realized at the orbits of magnetic flux tubes. This brings in mind strong form of holography (SH) implied by strong form of general coordinate invariance in TGD. Maybe honeybee dance is in certain sense a holographic representation?

6. The temporal size scale T of X would correspond to the duration of the dance and would thus code for the distance to the food source. Hence T must be more or less equivalent with the parameter α of Shipman. The electromagnetic charge Q generated during the flight of forager correlates also with the distance (1 second corresponds to 1 km) and also corresponds to T.

   T would naturally correspond to a finite size scale for CD assignable to the conscious self assignable to the honeybee dance.

7. It is quite possible that the full symmetry breaks down, and the intersection with X^4 gives only single geodesic in the torus $U(1) \times U(1)$. It is characterized by winding numbers (m, n). Waggle run involves two important frequencies: vibration frequency f_v of wings and waggle

frequency f_w: these frequencies could correspond to the two conserved Hamiltonians assigning two-momentum to the waggle orbit. These momenta would be equivalent with frequencies. If (f_w, f_v) corresponds to the pair (f_1, f_2) of rotation frequencies at torus $U(1) \times U(1)$ for the rigid body motion one would have $m/n = 20 = f_v/f_w$. The same frequency ratio appears in the system of plastic balls exhibiting life like properties [L47]. Could the dynamics of preferred extremals favor this value of m/n and give Ca^{2+} its unique role in biology and neuroscience?

14.4.5   Summary

The basic vision behind TGD view is that flag manifold coordinates represent geometric qualia and honeybee dance represents them. The choice of the subgroup $U(1) \times U(1)$ representing point of flag manifold is represented at space-time level. In TGD framework geodesic dynamics coupled to Kähler force is the physically attractive first guess since it would be 1-D idealization of the dynamics of classical TGD, which is obtained from this dynamics by replacing point-like particle with 3-surfaces. This dynamics follows from the twistor lift of TGD by dimensional reduction occurring dynamically. At the point-like limit it gives geodesic motion coupled to Kähler force and allowing $SU(3)$ charges as conserved charged. If one requires that also action $\int j \cdot A$ is invariant the symmetries reduce to $U(1) \times U(1)$ characterizing particular choice of Kähler function of CP_2 (it does not depend on coordinates (Φ, Ψ) assignable to $U(1) \times U(1)$).

The classical dynamics of TGD could explain how the map from the dual of $u(1) \times u(1)$ algebra to the space-time level - the beehive - is realized.

1. The orbits for completely integrable systems are parameterized by the conditions that maximal number of commuting Hamiltonians are constant. TGD is integrable theory and what suggests itself is that the Hamiltonians (P_Φ, P_Ψ) assignable to the phase angle coordinates (Φ, Ψ) parameterizing $U(1) \times U(1)$ orbit in CP_2 are constants at the projection X of the $U(1) \times U(1)$ orbit to X^4 the dimension $D(X)$ satisfies $D(X) \leq 2$. For $D(X) > 0$ the representation is dynamica.

   Space-time sheet could allows $D(X) > 0$ only for very few values of the momentum (P_1, P_2): the projections of other points of F would be discrete. One parameter subgroup of $U(1) \times (1)$ (torus orbit) would define the line H and its mirror image along magnetic flux tube. The edges of V would be obtained by π rotation from each other.

   Waggle run would correspond to time-like line and its spatial projection would represent the orientation angles (θ, ϕ) of the food source as those associated with with the diagonal of V. The temporal size T of X would determine the duration of waggle run and therefore the distance to the source. The electromagnetic charge Q generated to the abdomen of the bee during the flight is proportional to T of the waggle run and codes for the length of the path.

2. The natural parameterization of the situation is in terms of Darboux coordinates for CP_2 for which Kähler potential is given by $A = P_k dQ^k$. Using standard complex coordinates ξ_i for CP_2 [L2], one can choose Q_i to be phase angles of ξ^i: $Q_1 = \Phi$, $Q_2 = \Psi$. These coordinates are cyclic coordinates not appearing in Kähler function of CP_2 and they correspond to $U(1) \times U(1)$ isometries of CP_2. They are constants of motion also for the geodesic dynamics coupled to Kähler form. Conservation laws would correspond to the constancy of the corresponding Hamiltonians P_i. The orbit at X (or equal to it) would be therefore surfaces $P_i = constant$.

   The ratio $v = P_1/P_2$ would define the velocity $v = d\Psi/d\Phi$. The interpretation of P_i as frequencies is natural - hence the notation $P_i = \omega_i$ is more appropriate and an interesting possibility is that these frequencies could serve as a measure for the eagerness of the bee. An interesting possibility is that the frequencies f_v and f_w correspond to f_i. This would give $v \simeq 1/20$.

   X is intersection of HY with X^4. In so called Chladni mechanism [L35] for which self-organization patterns for charged particles correspond to the nodes of electromagnetic field so that the force vanishes. The situation would be exactly the same now but em field would be replaced by the induced Kähler form.

3. This picture would allow to understand why the two waggle runs become parallel at large distances and why they form V shape at smaller distances. Also the criticality could be understood. At criticality the second branch of V would become vertical and the geometry of the dance orbit would change so that waggle periods would be parallel to Earth and at opposite sides of the circle to code the information about the direction of the food source.

4. The waggle pattern characterized by the frequency f_w represents information related to the dynamics in M^4 degrees of freedom allowing perhaps only very limited number of continuous orbits. Also vibrational frequency f_v would represent additional information. The interpretation as cyclotron frequencies for Ca^{2+} and proton makes sense. These frequencies could correspond to the conserved momenta or equivalently frequencies associated with Ψ and Φ.

5. The rotation of the frame defined by the direction of Sun to that defined by the direction of local gravitation would correspond to a rotation of the MB of the bee. Here the permanent dark gravitational flux tubes would play a key role in defining the frame.

Needless to say, the proposed representation is very general and perhaps provide a universal manner to represent geometric information. Flag manifold qualia might be universal manner to represent geometric information. In the case of M^4 twistor lift forces to introduce the geometric variant of twistor space as $M^4 \times CP_2$ and also generalization of Kähler structure and symplectic structure. Now the counterpart of $U(1) \times U(1)$ consists of time translations and translations in some spatial direction and point of the twistor space correspond to a choice of time axis (energy quantization axis) and quantization axes of spin.

Chapter 15

Molecular Signalling from the TGD Point of View

15.1 Introduction

I learned recently about interesting findings about communications of information molecules. The Quanta Magazine article "*Biologists rethink the logic behind cells molecular signals*" (`https://cutt.ly/iA28lqn`) summarizes the findings of Elowitz *et al* described in the article "*The context-dependent, combinatorial logic of BMP signaling*" [I60] (`https://cutt.ly/yA8r07b`).

15.1.1 Observations

Messenger molecules attaching to receptors are thought to be responsible for chemical communications. Intercellular communications would involve first messengers (hormones, neurotransmitters,...) and intracellular communications second transmitters, which are not proteins but rather light molecules.

The standard interpretation has been that messenger molecules themselves define the message. Lock-key hypothesis states that the ligand has a special region (key), which attaches to the receptor in a context independent way determined by the geometries of these regions. Induced-fit hypothesis states that the regions in question can modify their surfaces to achieve a perfect fit. For bacteria only intracellular communications are possible and for them there is evidence that in some special cases lock-and-key principle works as was demonstrated by Michael Elowitz, the leader of the research group behind the recent work.

The findings of the Elowitz and his coworkers force them to conclude that this model fails for the multi-cellulars.

1. The group studied so-called bone morphogenetic proteins (BMP) (`https://cutt.ly/oA7kZna`), which regulate how cells proliferate and differentiate in various tissues by directing them to turn sets of genes on and off. These proteins have many other functions than bone growth.

2. BMPs are so-called 1st messengers and mediate communications between cells. BMPs attach to the receptors of various types at the surface of the cell. This step is followed by signal transduction activating the corresponding signalling pathway. Eventually this leads to a generation of transcription factors in the cell nucleus controlling the genetic response. The work concentrated on the study of the binding of BMPs to the receptors at the cell membrane.

3. Mammals have genes that encode 11 or more distinct BMP proteins. BMPs occurs dimeres of the same or different proteins and also these pairs can pair up. The family of BMP proteins sticks to the associated family of receptor proteins, which also appear as dimers of pairs of them. BMP molecules are not very selective but given BMP sticks to several dimer pairs of receptors.

Several interesting findings were made.

1. The response of a cell to several ligands is not simply the sum of responses of individual ligands. The lock-key mechanism assuming 1-1 correspondence between ligands and receptors fails in the presence of several ligands whereas for a single ligand there is strongly preferred receptor for a given ligand.

   The simplest chemical (and thus local) explanation that in presence of several ligands the affinities K_{ijk} of ligands L_i to the receptors R_{jk} formed by dimers (j,k) of homologous or nearly homologous molecules change so that approximate 1-to-1 correspondence becomes 1-to-many. This is called promiscuity.

   The responses as concentrations at the cell membrane for the activated signalling pathways P_{ijk} associated with receptor i+jk would be still linear in concentrations of L_i but the matrix characterizing the rate for the creation of P_{ijk} would not be diagonal matrix anymore with respect to pairs (i, jk).

2. This situation is easy to model mathematically but it is difficult to understand the physical mechanism behind the promiscuity.

3. The affinities are context dependent in the sense that they depend on the target cell and the developmental stage of the cell.

4. One can classify the ligands in terms of whether they tend to increase or reduce receptor expression. Ligands can be also classified in terms of their positive, or negative synergies with other ligands. In the simplest situation one studies all possible pairs of ligands and finds their responses. Two ligands L_i and L_i are regarded as equivalent if the responses for the pairs (L_i, L_k) and (L_j, Lk) are identical for all k. This defines functional equivalence. Sequence similarity (biological homology) does not in general reflect the functional equivalence.

   The effects of the ligands in equivalence classes depend on the context (cell type and cell age correlating with receptor concentrations). However, it is found that the equivalence classes are context independent. The proposal is that a single linear parameter could characterize the equivalence classes for BMPs considered.

5. This inspires a chemical model for the situation. The basic parameters would be affinities K_{ijk} telling the tendency of ligand L_i to attach to dimer (j, k), signal complex activities ϵ_{ijk} characterizing the rate for the formation of signal complex P_{ijk}. Also the receptor concentrations A_i and B_i for the receptors of type I and II appear as parameters. The empirical data makes it possible to find the best fit for the parameters. Promiscuity is the basic prediction. The model could be understood in terms of the competition of ligands for receptors (j,k).

   An inverse relationship between affinities and activities is predicted. Small number of affine ligands with weak activity or vice versa.

15.1.2 TGD view about the findings

What can one say about the situation in the TGD framework? Here only the key ideas of the TGD inspired quantum biology are described. More detailed summaries can be found in various articles related to dark variant of biochemistry [L145, L46, L109], to dark realizations of genetic code [L19, L101, L75, L108, L123], and to the models for cell membrane as generalized Josephson junction [K92, K44, K95] [L107], of Pollack effect [?], and of water memory and morphogenesis [K53] [L122].

1. The basic notion is magnetic body (MB) carrying dark matter as $h_{eff} = nh_0$ phases of the ordinary matter and behaving quantum coherently in length scale proportional to h_{eff}. MB would control biomatter.

   Communications to MB, sensory input, would be in terms of generalized dark Josephson radiation from the cell membrane and the control by MB in terms of dark cyclotron radiation. The sensory input would be from the entire cell membrane and induced by the attachment of the ligands to the receptors.

The earlier proposal was that the control signals from MB affect directly the genome. The existing chemical picture based on signal pathways activated at the cell membrane however suggests that the situation is not so simple. The control signal arrives from MB to the receptors and activates signal pathways. At the nuclear membrane similar processes would occur and lead to the activation of transcription factors by similar signal pathways.

2. If the MB determines the response of receptors in a non-local way, promiscuity could be only effective. Another option is that MB can control the affinities of receptors (by modifying their surface geometries as in the induced fit model) so that the diagonal L-R matrix becomes non-diagonal.

3. Context dependence would conform with the idea that MB determines the response and changes during aging. The aging can be understood in the TGD framework as slow thermalization of MB so that its temperature approaches the Hagedorn temperature of magnetic flux tubes. Physiological temperature would be related very closely to Hagedorn temperature of MB.

The almost computer program-like determinism of biochemistry is in a sharp conflict with the stochasticity expected to result from the locality and statistical nature of chemistry.

1. In the TGD framework and at a given level of scale hierarchy the dynamics of the space-time surface as a preferred extremal is deterministic apart from small violations of determinism. Space-time region as a preferred extremal is a minimal surface with singularities, which would bring in the failure of determinism. Soap film with frames serves as a good analogy.

2. The notion of a magnetic body having flux tubes as body parts leads to a model of bio-catalysis in which molecules are replaced with nodes of flux tube network. Molecules can find each other as part of this dynamical network involving reconnection of U-shaped flux tubes and their shortening in a reduction of h_{eff} liberating energy making to overcome the potential wall making the reaction low.

3. One can argue that the second law implies stochasticity in molecular scales. Zero energy ontology (ZEO) is another possible source of determinism. In so called "big" state function reductions (BSFRs) the arrow of time changes and the time evolution leads to the direction of geometric past so that for the observer with the standard arrow of time the time evolution obeys second law in wrong time direction and looks like self-organization which is basic characteristic of living matter and usually thought to involve metabolic energy feed in an essential way. In fact the time reversed time evolution would change dissipation as loss of energy with extraction of energy from the environment.

The findings of Elowitz *et al* [I60] lead to a formal model suggesting that ligands of type BMP have interactions. The interactions would be non-local so that that they could have chemical origin. The TGD based model for these long range interactions is based on dark photon resonance. For the simplest, receptors would correspond to fixed bio-harmonies. In a single ligand system the ligand would have the bio-harmony of its preferred receptor. The interaction between ligand magnetic bodies would be re-tuning and could replace the preferred bio-harmonies assignable to the participating ligands with distributions of bio-harmonies. Therefore the ligands of the multi-ligand system would couple by bio-resonance also to other than preferred receptors.

The model stimulates questions, which lead to a rather detailed model for the re-tuning and tuning processes at the level of codons and amino acids. The model suggests that the tuning to a given bio-harmony for the dark counterparts of basic biomolecules and its stabilization involves epigenetic control based on the methylation of some special DNA and RNA nucleotides and amino-acids acting as analogs of tuning forks.

The proposal that bioharmonies are molecular correlates for emotions suggests that this process involves minimal number of methylations, which define the seed of phase transition to a bio-harmony in the scale of the basic unit of genome (such as gene), mRNA sub-unit (splicing) and protein sub-unit.

15.2 Bio-harmony and context dependence

Also bio-harmony might relate to context dependence if fundamental communication and control signals take place at the dark level that is between DAAs instead of AAs (amino acids) as parts of proteins by energy and frequency resonances. DAAs would pair with AAs and communicate with energy resonance.

15.2.1 Bio-harmony

Consider first the bio-harmony [L19, L75, L101, L123] in more detail.

1. Z_6, Z_4, and $Z_{2,rot}$ or $Z_{2,refl}$ act as symmetry groups for the 3 icosahedral Hamiltonian cycles. Each cycle, one of type XZ_6, one of type Z_4, and one of type Z_2, defines 12-note scale and 20 3-chords identified as icosahedral faces and DNA codons. The notes along the cycle are obtained as a quint cycle, that is by scaling the frequency of the note by factor 3/2 at each edge of the oriented cycle.

   The orbits of faces under Z_n are assigned with amino-acids (AAs). This assumption has a concrete interpretation in terms of resonance mechanism for bio-communications [L123].

   This gives 60 3-chords and the numbers of triangles at the orbits of triangles and the numbers of triangles at orbits correspond nicely to the numbers of DNA codons coding for AAs. 4 codons are however missing. The fusion with a unique tetrahedral code gives 64 chords and a dark 3-photon realization of the genetic code.

   Also the identification of DtRNA, dtRNA, and DAA in terms of icosahedral code is possible as found quite recently [L123]. Also the dark realization of genetic codons in terms of dark proton triplets allows this.

2. Z_6 allows unique icosahedral harmony defined by 12-note scale realized as an icosahedral Hamiltonian cycle. The corresponding AAs correspond to 3 DNA 6-plets and one DNA 2-plet. Z_4 corresponds to 2 bioharmomies with 5 amino-acids which correspond to DNA 4-plets. $Z_{2,rot}$ and $Z_{2,refl}$ correspond to 10 2-plets both. $Z_{2,rot}$ corresponds to 3 icosahedral harmonies and $Z_{2,refl}$ to 5 icosahedral harmonies. This makes $1 \times 2 \times (3 + 5) = 16$ bio-harmonies if the common key of the 12-note scale for the 3 icosahedral harmonies does not matter and the orientation of the Hamiltonian cycle does not matter. One can also consider the possibility that the key and the orientation of the cycle for the 3 icosahedral harmonies matter. The change of the orientation replaces quint cycle with quart cycle (CG corresponds to quint and CF to quart).

3. The interpretation of bioharmonies is as correlates for moods, emotional states. There is evidence for this interpretation from the strange finding that RNA is able to transmit conditioning based on negative or positive emotions generated by stimulus (`https://cutt.ly/6SuLNqk`) discussed in the TGD framework in [L64, L82]. The interpretation would be that DRNA represents the effect of stimulus by its bio-harmony characterizing emotional state, and can induce molecular emotional expression in DDNA-DNA pairing and also in DAA-AA pairing and DX-X pairing in general.

   DX-X pairing by energy resonance mechanism would correspond to emotional expression. Something in X would depend on bio-harmony. In the case of DNA and RNA this something could be the methylation state and its analogs so that there would be a direct connection with epigenesis. Epigenesis would realize the dynamics of emotional expression.

   One can raise several questions about bio-harmony.

1. How fast is the dynamics of the molecular and higher level emotions and moods? If epigenetics controls the dynamics of emotions, it could be rather fast at the molecular level. Note that the hierarchy of Planck constants predicts a hierarchy of time scales.

2. How large parts of a given organism a given bio-harmony could characterize? Biomolecules, cell nucleus, cell, organelle, ...? Is there a hierarchy of harmonies so that the harmonies in different scales need not be identical?

Concerning molecular bio-harmonies, epigenetics could help to answer the question. For instance, one can ask whether bio-harmony characterizes individual bio-molecules such as enzymes and receptors.

3. Could bio-harmony explain at least part of the context dependence found in the ligand-receptor dynamics by the group of? It would seem that bio-harmony appears as an additional aspect of the ligand-receptor pairing involving geometric constraints modelled in terms of lock-key or induced-fit mechanisms. The enzyme and substrate would be like daters. The resonance mechanism would allow E and S to meet and geometric constraints would determine whether this can lead anywhere.

4. This inspires several questions. Could the affinities and signal complex activities be determined by the molecular emotional state of the L-R composite coded by the bio-harmony of the DX-X complex? Could the "emotional" state DX-X control affect the state of X complex? How? Could this coupling have interpretation as emotional expression in a generalized sense?

5. For the simplest model this would predict that for Z_4 the 5 AAs coded by 4 DNA codons would have two emotional states and for Z_2 10 DAA-AA pairs could have 3 *resp.* 4 emotional states depending on whether one has $Z_{2,rot}$ *resp.* $Z_{2,refl}$.

15.2.2   Could ligand interactions reduce to a re-tuning of ligand harmonies?

The notion of ligand interaction has been introduced as a purely formal notion in the article and it is difficult to imagine a local chemical realization for it. However, the fact is that ligands change their behavior in the presence of other ligands. Could the ligand interactions be realized at the level of their MBs?

Ligand interactions as re-tuning

Could ligand interactions reduce to the re-tuning of ligand harmonies by the resonant dark photon interactions between DAA flux tubes?

1. Assume that ligands and receptors can have several bio-harmonies but that free ligands (single ligand situation) and in the absence of other ligands they correspond to single preferred bio-harmony. Assume that each receptors corresponds to a single bio-harmony (also this assumption could be relaxed). Free energy minimization could imply preferred bio-harmonies for both receptors and ligands. Assume that ligands can only pair with receptors with the same bio-harmony. The immediate question is whether the 3+4 receptors assigned with BMPs could relate to 3+5 Z_2 type harmonies. The problem is that one $Z_{2,refl}$ harmony would not correspond to a receptor.

2. Interactions between two ligands L_1 and L_2 with different bioharmonies could induce a re-tuning of L_1 to the bio-harmony of L_2 or vice versa. This tuning must respect the symmetry group Z_n, $n = 6, 4, 2$ in question. The Z_n orbits would be preserved but the corresponding 3-chords would be modified.

   Some findings about water memory [L122] support re-tuning as a basic mechanism of communications between dark biomolecules and it is very natural in the resonance picture. Note that re-tuning is a basic mechanism in radio communications.

   Re-tuning would replace the ensemble of ligands with an ensemble in which also non-preferred L-R pairings are possible. It would make the affinity matrix $K_{i(jk)}$ and activity matrix $\epsilon_{i(jk)}$ non-diagonal and induce promiscuity. Probability distribution for bio-harmonies of ligands would emerge in this way.

3. The large-scale quantum coherence at the level of MBs inspires the question whether the quantum superposition of bioharmonies could occur for DAAs.

Could quantum superposition allow to understand the observation that the increase of the parameters $K_{i(jk)}$ is accompanied by the decrease of $\epsilon_{i(jk)}$ and vice versa. Could one think that with a suitable normalization one has $\sum_{(jk)} K_{i(jk)}\epsilon_{i(jk)} = constant$. In ZEO one could regard the entire signal complex, which involves both ligand, receptor and what it induces, as a single zero energy state as a superposition of deterministic time evolutions.

If the formation of signal complexes involves a quantum transition from a single ligand-receptor pair to a their quantum superposition involving delocalization at the cell membrane followed by state function reduction involving localiation that is selection of the complexes, the condition $\sum_{(jk)} K_{i(jk)}\epsilon_{i(jk)} = constant$ could reflect probability conservation.

4. Re-tuning of the icosahedral harmony for Z_4 and Z_2 should have a counterpart affecting the physics of AAs. Could the re-tuning be generated at the level of DAA and result from the variation of flux tube thickness as a motor action of MB? Or could it be induced by re-tuning at the level of DDNA? Tuning must be visible at the level of AAs since DX-X resonance energies must be modified.

Tuning and re-tuning at the level of DX-X pairing

What could the re-tuning mean for the DX-X pairing?

1. For DDNA-DNA pairing dark cyclotron photons must couple to some degrees of freedom of DNA. In the TGD framework, DNA can be magnetized [L122]. The pairing with DDNA flux tubes carrying a monopole flux with DNA strands is expected to induce magnetization along DNA due to the ring currents of electron pairs of the aromatic rings analogous to Cooper pairs.

   The simplest candidates for re-tuned frequencies are cyclotron frequencies for magnetized nucleobases. In re-tuning the cyclotron frequencies for electron pairs) assignable to aromatic rings of nucleotides would be modified in re-tuning. The change of the thickness of the monopole flux tubes defining the 12-note scale would automatically induce the re-tuning at DNA level. The re-tuning could be induced by DDNA, DRNA, and DtRNA and would not require chemistry.

2. What about the DAA-AA tuning? The only AAs with aromatic rings are Phe, tyr and trp. Could DAA-AA resonance coupling between cyclotron radiation of DAA and vibrational modes of AA with energies in the range .45-.045 eV spanning slightly more than 3 octaves?

   The general forms of the vibrational and cyclotron energy spectra are the same and for a proper value of h_{eff} the scale of the DAA spectrum is the same and resonance is possible.

   Re-tuning would require change of the conformations of the AAs so that the elastic constants would be modified. MB could induce this re-tuning as a kind of entrainment. As already proposed, this could be achieved at the level of DNA by methylation of the start codon fixing the bio-harmony.

Could special 3-chords act as tuning forks

Physical model for the tuning and re-tuning should be based on resonance model.

1. Tuning to a particular 3-chord or 3-chords should force the entrainment to the bio-harmony. These 3-chords would serve as an analog of a tuning fork.

   The simplest, and perhaps unrealistic, option is that the met 3-chord associated with the start codon alone fixes the bio-harmony uniquely. The met 3-chord should be different for all Z_2 harmonies.

2. The chords fixing the bio-harmony (the tables for the 3-chords of bio-harmonies are given in [L19]) should be very special and thereindeed are very special chords in the icosahedral harmonies. The epigenetic modification of the amino-acids corresponding to these 3-chords could force the re-tuning of the bio-harmony.

The triangles, whose edges do not belong to the Hamiltonian cycle, define 0-quint 3-chords containing no quint. These chords include dissonant chords possibly having semitones or tones intervals between the notes (octave equivalence and quit cycle along the Hamiltonian cycle is assumed). There are 8 different types of 0-quint chords with basic note X in 12-note scale labeled as $Xexk, k = 1, .., 8$, if the key does not matter.

1. From the Appendix one learns that there the first possess no 0-quint chords Z_4 harmony. In this case, one could argue that the bit defined by the presence or absence of the 0-quint chord defines the tuning fork, which could correspond to a methylation of some codon coding for one of the 5 AAs coded by DNA 4-plet. It is not clear, whether the choise of the codon matters.

2. By looking at the tables of 3-chords in the chord tables of the Appendix, one finds that if key matters, it is easy to distinguish between harmonies using a single 0-quint chord. If the key does not matter, it is in principle almost possible to assign different 0-quint chords to, say, met. There are 2 $Z_{2,refl}$ harmonies with 2 0-quint chords, which cannot be distinguished in this manner. If one introduces a fixed key or uses a second special 0-quint chord as a turning fork, also $Z_{2,refl}$ harmonies can be distinguished from each other.

   Interestingly, the number of BMP receptors possibly assignable to $Z_{2,refl}$ is 4 rather than 5.

3. Also tetrahedral codons define special chords in the sense that the intervals are separated by minor third. These 3-chords are identical under the octave equivalence. In the model considered in [L123], 3 of them correspond to stop codons whereas the remaining codon corresponds to trp.

Re-tuning as an epigenetic process

Re-tuning is an epigenetic process and can be seen as a control of MB. Methylation and its analogs are basic tools of epigenesis.

1. mRNA methylation (`https://cutt.ly/1Srm06F`) occurs after transcription and is controlled by genes coding the needed enzymes. The methylated RNA nucleobase is often called the "fifth RNA" base. Start codon AUG coding for met is methylated as also the 3-prime untranslated regions (3'-UTRs) immediately after the stop codon. This region post-transcriptionally influences gene expression.

2. The findings that the RNA of a conditioned sea snail scattered over neurons of second sea snail in Petri dish generate neuronal correlates of conditioning (`https://cutt.ly/6SuLNqk`), discussed from the TGD point of view in [L64, L82], support the view that the magnetic body of the RNA of sea snail infects the emotion/mood related to the conditioning. The emotional state, mood, of DNA and RNA would affect gene expression. Epigenesis could be based on emotional states lasting for several generations. This is natural in ZEO [L19, L82].

Hints about how the methylation could be involved with the tuning to a particular bio-harmony comes from the research of the group led by Matthias Soller [I57] (`https://cutt.ly/0SeGnJu`).

1. Post transcriptional methylation is known to occur for the few nucleotides of mRNA following the cap of mRNA, whose function has remained poorly understood. Soller and collaborators demonstrated that the two enzymes coding for the methylation of these nucleotides played an important role in the animals' reward learning process. The flies without the genes coding for the methylation showed a defect in their ability to learn the association of a specific odour with a sugar reward.

2. Earlier work by one of paper's co-authors, Prof. Rupert Fray, has demonstrated that that cap modifications are highly dynamic in mice and that these modifications played a role in transporting the mRNAs to synapses.

3. The lack of methylation implies a lack of the desired conditioning. Conditioning involves emotions, perhaps also at the molecular level: could the bio-harmony of proteins involved with the process differ from that associated with the protein activated by the odour molecules? The proteins would be out-of-tune and conditioning would not happen.

The role of cap modifications in the mRNA transport would conform with the assumption that dark photon resonance allows the mRNA to find synapses. If the bioharmony for them is wrong there is no resonance and the transport fails.

These findings suggest the following interpretation in the TGD framework.

1. The resonance mechanism would force DDNA and DmRNA to have the same bio-harmony. The post-transcriptional methylation of the first RNA codon could re-tune and stabilize mRNA bio-harmony.

Stabilization could involve a methylation of a large enough number of special RNA codons so that it would serve as a seed of a phase transition forcing the same bio-harmony for all codons. If bio-harmonies correspond to molecular moods, this would be analogous to the spread of an emotional mood in crowd. The special codons as signatures of the mood could be especially effective inducers of this phase transition.

2. Could a 0-quint 3-chord assigned to met in the beginning of mRNA fix the Z_2 harmony almost uniquely by acting as a tuning fork. Z_4 harmony could be fixed by the absence of methylation in some mRNA nucleotide in codon coding for one of the 5 AAs [(val,pro,thr,ala,gly)] coded by 4 codons.

Note that the methylation of 2 AUG nucleotides of met affecting the cyclotron frequencies of AUG could in principle select between the 16 bio-harmonies predicted by the simplest model. This estimate is however based on counting of bits and bio-molecules need not see each other as bit sequences as we do.

The methylation of the mRNAs associated with several 0-quint chords could help to stabilize the Z_2 harmony at the level of DmRNA. Could the proteins obtained by splicing and involving methylation in the beginning of mRNA portions coding them consist of functional sub-units with different bio-harmony?

3. What about DNA? Could the methylation of the start codon also now help to stabilize the Z_2 bio-harmony. Only A and C DNA nucleotides of DNA strand can be methylated (as also T and G nucleotides of the conjugate strand). Note that A and G appear often in DNA repeats defining part of what was called junk DNA. One can ask whether the methylation of A and C could stabilize the bio-harmony and DNA level.

The corresponding RNA codon contains at most one U or G nucleotide. Note that met corresponds to AUG whereas AGU corresponds to cys which together with trp (coded by tetrahedral codon) are the only sulphur containing amino-acids. Met is special in the sense that it belongs to a symmetry broken codon doublet for which ile has replaced met.

4. The first mRNA codon AUG codes for met so that the D(AUG)-Dmet pairing could induce the DAA bio-harmony and affect the vibrational frequencies of AA. This is perhaps enough for the stability of the bio-harmony. Could pretein methylation help to stabilize the bio-harmony of proteins? According to Wikipedia (`https://cutt.ly/uSiVACT`), protein methylation is a type of post-translational modification featuring the addition of methyl groups to proteins. It can occur on the nitrogen-containing side-chains of arginine and lysine but also at the amino- and carboxy-termini of a number of different proteins.

One can imagine 2 options for changing the bio-harmony at DAA-AA level. For the bureaucratic option, the re-tuning would occur at the DNA level. This would require enzymes coded by appropriate genes to re-tune the first codon of mRNA coding for AA.

For the non-bureaucratic option, DAA would re-tune AA directly by entrainment and this could involve re-methylation.

15.2.3 An attempt to concretize the model of ligand interactions

The following is a very naive first attempt to concretize the idea about ligand interactions as a re-tuning, whhich affects the matrices $K_{i(jk)}$ and $\epsilon_{i(jk)}$. Reader should take the following considerations as as free associations.

1. BMPs couple to 4+3 receptors. There are 3 Hamiltonian cycles with $Z_{2,rot}$ symmetry and 5 cycles with $Z_{2,refl}$ symmetry assignable to 10 amino-acids coded by 2 or single DNA (met) have 3. There are 4+3 receptors and 5+3 bioharmonies: could it be that the considered 4 receptors correspond to 4+3 Z_1 harmonies with the same Z_4 harmony and that there is also a fifth receptor of this kind but not considered?

   A priori, any protein could correspond to any bio-harmony but the correlation of DAA and bio-harmony could be forced by dynamics since the DAA-AA resonances might be possible only for certain Z_2 harmonies (and only for one of the 2 Z^4 harmonies). Suppose that the receptors indeed correspond to one particular Z_2 harmony each.

2. If the binding sites for BMP-receptor pairs correspond to single AA (in analogy with tRNA-mRNA binding), the binding site for Z_2 harmonies should correspond to a AA which is one of the 10 AAs coded by DNA doublet or singlet. The reduction of correspondence to the level of binding site AA would conform with the finding that the functional similarity of BMPs does not very closely correspond to the sequence similarity.

   In the code table there are 9 doublet AAs and 1 singlet. Symmetry breaking is present [L123]. It is not quite clear which doublets correspond to Z_2. For instance, phe could correspond to the doublet for Z_6 leaving 8 doublet AAs plus (ile,met) as a doublet with a broken Z_2 symmetry. UGG coding for trp and 3 stop codons would correspond to the tetrahedral cycle.

   By resonance condition, at most 3 receptors should correspond to more than 1 BMP as their preferred receptor.

There are also chemical constraints on the AAs acting as a binding site. Resonance condition for DAAs implies that pairing AAs are identical. The pairing AAs must be neutral and must be coded by DNA doublets or singlets. This leaves the following cases under consideration.

1. Two amino acids have amide side-chains.

   - Asparagine (Asn): $NH_2 2COCH_2$-

   - Glutamine (Gln): $NH_2 2COCH_2 2CH_2$

   These side-chains do not ionize in the normal range of pH.

2. Two side-chains contain sulfur atoms, of which one ionizes in the normal range.

   - Cysteine (Cys): $HSCH_2$-

   - Glutamine (Gln): $NH_2\text{-}COCH_2\text{-}CH_2$-

3. Three amino acids have aromatic ring structures as side-chains. Of these, tyrosine ionizes in the normal range; the other two do not.

   - Phenylalanine (Phe)

   - Tyrosine (Tyr)

   - Tryptophan (Trp)

This would give 2+2+3 =4+3 AAs. In the above mentioned option Phe is however assigned with Z_6 harmony but any other doublet AA could correspond to Z_6 harmony. This would suggest that AAs with amide side chains and containing sulphur correspond to 4 $Z_{2,rot}$ harmonies.

There are 10 BMPs with the decomposition 10=3+3+2+1+1. Using the standard biological notation, this correspondings to the decomposition [GDF5,GDF6,GDF7], [BMP5,BMP6,BMP7], —BMP2,BMP4],[BMP9], [BMP10]) to functional equivalence classes [I60]. Could the two 3:s correspond to the 3 $Z_{2,rot}$ harmonies and 2+1+1 to 4 of the 5 $Z_{2,refl}$ harmonies?

The two triplets [GDF5,GDF6,GDF7] *resp.* [BMP5,BMP6,BMP7] are weak *resp.* strong activators. Both GDFs (growth differentiation factors) and BMPs (bone morphogenetic proteins) belong to the transforming growth factor beta superfamily (TGF). If GDFs are excluded the correspondence between BMPs and receptor proteins is 1-to-1.

15.2.4   Could the dark matter hierarchy relate to the bio-harmony?

One can wonder how the hierarchy of algebraic extensions and algebraic evolution defining the evolutionary state for a given layer of MB affects the L-R pairings.

1. Dark 3N-photons and 3N-nucleons as dark variants of basic information molecules would correspond to Galois confined states for which the 4-momenta for components are algebraic integers summing up to ordinary integer when the momentum unit is defined by the p-adic length scale associated with the extension. Also frequencies would correspond to rational integers for Galois confined states.

2. These states depend on the algebraic extension of rationals defining $n = h_{eff}/h_0$ as its dimension although mass squared values and momenta are integer valued as also frequencies. This would give an additional context dependence. For instance, organisms at higher levels of evolution could have larger values of h_{eff} associated with the dark variants of the basic biomolecules.

15.3   Hen egg problem, dark biomolecules, and resonance mechanism

The notions of magnetic body, dark matter as $h_{eff} = nh_0$ phases, dark analogs of information molecules, and resonance mechanism could allow a solution to the hen egg problem of biology: which came first, DNA, RNA, AAs or proto-cell membrane. I have considered the hen egg problem in [K69] and proposed a model of proto-cell in [L98].

Hen egg problem usually means that something is missing from the conceptual picture and TGD based quantum biology suggests what this missing piece could be. The general solution of the problem in TGD would be that dark analogs of information molecules emerged first simultaneously as Galois confined states of dark proton-triplets and dark photon-triplets.

This made possible resonance communications and the basic recognition mechanism by 3-resonance for dark 3-photons. DX-X pairing was based on energy resonance and these composites were able to find each other by resonance. The reduction of h_{eff} for connecting flux tubes in their shortening liberated energy making it possible to overcome the potential wall preventing chemical reactions to occur. This is not as easy as it looks at first since metabolic energy is needed to build the valence bonds and metabolic machinery is absent in early life.

The challenge is to develop a more detailed picture around these basic ideas. I have already earlier considered several proposals for the first steps of the evolution of basic bio-molecules [K47, K48, K69] but without the recent, rather detailed, view about resonance mechanism combined with the notion of dark 3N-photons and 3N-nucleons as dark analogs of basic biomolecules [L123].

15.3.1   Did the DX-X pairing occur simultaneously for all basic biomolecules?

Consider first the pairing of basic information molecules X (DNA, RNA, tRNA codons and AAs). Their polymers are not considered in this section. The simplest vision is that the dark variants of basic biomolecules emerged by Pollack effect [I92, I91, L23, I126, I147] in water irradiated by solar light.

1. Pollack effect generated exclusion zones (EZs) as negatively charged regions. Part of protons were transferred to magnetic monopole flux tubes of MBs assignable to water clusters and created phases of water with a hexagonal lattice-like structure.

2. An attractive possibility is that the notion of hydrogen bonds generalizes. The monopole flux tubes could be accompanied by hydrogen bonds. This predicts a length scale hierarchy of hydrogen bonds implying long range quantum correlations in arbitrarily long scales and allowing to understand the strange thermodynamic anomalies of water. The length of the dark flux tube is proportional to h_{eff} as also the total energy consisting of Kähler magnetic and volume contribution.

3. Galois confinement as a universal bind mechanism would give rise to sequences of dark protons as bound states. The states of dark proton triplet correspond to DDNAs, DRNAs, DtRNAs and DAAs.

   The pairing of the dark analogs of biomolecules with ordinary biomolecules to form pairs DX-X gave rise to the observed basic biomolecules. DX-X pairing requires that the ordinary biomolecules have transition energies, which correspond to the cyclotron transition energies of DX for the value of h_{eff} considered. Ordinary cyclotron transitions and vibrational transitions are good candidates in this respect.

4. Energy resonance condition for the pairs gives powerful conditions and selects the allowed biomolecules. The selection has not been completely unique. In tRNA the third letter of the chemical codon paired with one of the 32 DtRNAs need not be an ordinary nucleotide and in some viruses adenosine (A) is replaced with 2-amino-adenine ("Z") [I69] (`https://cutt.ly/hSRBS0K`).

15.3.2 Did proto-cell and peptides emerge first?

It is not at all clear whether the dark variants of the polymers of basic bio-molecules can emerge spontaneously. The problem is that the formation of valence bonds requires energy. This forces us to consider the TGD counterparts of the usual purely chemical proposals in which basic building bricks DNA, RNA and AAs form polymers. Now one considers an analog of polymerization at the level of DDA, DRNA, and DAA.

   The findings of Montagnier *et al* [I66, I65, L94] discussed from the TGD view point in [L122] suggests that remote DNA replication occurs in absence of DNA template but that the presence of DNA polymerase is necessary. Dark DNA sequences generated by remote replication would appear as a template. This suggests DDNA-DNA pairing could occur by polymerization and require the presence of enzymes and metabolic energy feed.

   Could proteins (Ps) have served in the role of egg in the chemical sense in the TGD framework? Could the resonance mechanism together with the TGD view about bio-catalysis make it possible to generate DP-P pairs by a polymerization-like process using DP as a template?

1. The large h_{eff} between DP and P would be shortened in a given polymerization step. Energy would be liberated as the dark flux tube bond between DP and P is shortened. This energy should make it possible to overcome the potential wall preventing the formation of the peptide bond and also provide the energy of the peptide bond, which is about .08-.16 eV and considerably smaller than metabolic energy quantum about .5 eV.

2. The thermal energy at room temperature using the definition $E_T = kT$ is .025 eV. Second definition of thermal energy is as the energy for which the distribution of black-body radiation as function of energy is maximum: this gives the energy is $E_T \simeq .12$ eV and rather near to the Josephson energy of the cell membrane for charge Z= 2e is about .1 eV.

3. The energetic requirements for AA polymerization might be satisfied by using irradiation with photon energy around thermal energy at room temperature. An interesting possibility considered in [K69] and [L98] is that a proto-cell membrane formed from lipids was present from the beginning and before the polymerization. Lipid membranes can form spontaneously and in TGD Universe they act as generalized Josephson junctions [K92, K95] and induce Josephson radiaton, which would make possible communications from cell membrane to MB.

Could the Josephson radiation from the cell membrane with energy of order .1 eV provide the metabolic energy for the polymerization process of AAs?

4. In the case of DNA and RNA the carbon bond energy between two codons is about 3.2 eV and considerably larger so that the polymerization without enzymes looks highly implausible. Note also that also the formation of lipids is a problem since C-C bonds have energy 3.47 eV.

15.3.3 Empirical and experimental support for the model of peptide formation

There is evidence for amino acid glycine in the interstellar space (`https://cutt.ly/HSYQPmP`) but the independent confirmation is lacking. Also the formation of glycine peptides has been observed in laboratory conditions mimicking the interstellar medium (ISM).

The following summarizes the results described in the article of Serge Krasnokutski *et al* [I61] published in Nature. The following summarizes Krasnosutski's non-technical description of the results (`https://cutt.ly/dSYm1Sn`).

1. The ultra-low temperatures, common in astrophysical environments, have been believed to freeze out any chemistry in the dense areas of the ISM. Already the discovery of a high abundance of small organic molecules in molecular clouds was a great surprise. But also the formation of amino acids, nucleobases, lipids, and sugars in space has been confirmed.

2. What about the polymers of AAs? It has been conjectured that the condensation of carbon atoms at the surface of dust particles make possible the formation of organic molecules. Serge Krasnokutski *et al* indeed demonstrated the formation of glycine polymers from amino ketenes (glycine corresponds NH_2-CH_2-COOH, aminoketene to NH_2-CH-CO and polyglycine to NH-CH_2-CO) under laboratory conditions simulating the ISM conditions at temperature T=10 K (`https://cutt.ly/3SYT169`). A spontaneous(!) formation of relatively short peptides (less than 10-11 monomeric units) was found. The polymerization of amino acids under energetic processing (e.g. heat, pressure, or UV irradiation) is known to occur. Therefore, a further increase in chain length can be expected in natural environments.

Moreover, by adding other species instead of a proton to the α-carbon atom of amino ketene (nearest to the functional group) during the polymerization, a variety of different peptide chains can be formed. Furthermore, chemical and photochemical modifications of glycine residues in peptides into other amino acid residues were also demonstrated in many works. Thus, the glycine peptides observed in our experiments can be converted into different proteins.

3. These findings fit nicely with the proposed mechanism for the formation of proteins (or at least short peptides). The mechanism is not chemical, and no radiation is needed since the generalized Josephson radiation would provide the energy of the AA-AA bond, and the formation rate does not vanish at ultralow temperatures.

15.3.4 How did lipids, small organic molecules, and DNA and RNA polymers emerge?

There is a temptation to say that after the emergence of proto-cell membrane and peptides, the rest was history. This is not so simple.

1. The formation of the proto-cell membrane could occur spontaneously if lipids are available. Lipids however have C-C bonds with bond energy 3.47 eV and C==C bonds with energy 6.28 eV. These energies are in the UV range.

2. Also the energies of valence bonds associated with DNA, RNA, and also other basic biomolecules are in this range. The freezing of the chemistry at ultralow temperatures does not allow the generation of these bonds since the metabolic machinery provided by ATP molecules is not present. Simple organic molecules and even amino-acids are however detected in the interstellar medium. It seems that life-as-nothing-but-chemistry dogma must be wrong.

3. The Josephson radiation associated with proto-cell membrane with an energy scale of .1 eV could help in the formation of peptides but cannot help in the more general case. Could the splitting of a hydrogen bond provide the metabolic energy quantum of .5 eV in the absence of ATP machinery? The formation of water involving O-H bonds and their dynamics at temperatures of few K do not sound plausible unless one leaves the framework of the standard chemistry.

Metabolic machinery involves a lot of control and the standardization made possible by the metabolic energy quantum. This involves a lot of control. What could have served as a controller and energy source for bond formation at ultralow temperatures of few Kelvin and in the absence of the complex metabolic machinery based on ATP. In the TGD Universe, MB carrying dark matter is the answer to the question.

1. The existence of B_{end} was originally deduced by Blackman [J28] and other researchers. They found that ELF em fields had quantum-like effects on the vertebrate brain. These effects could be understood in terms of cyclotron transitions in the "endogenous" magnetic field $B_{end} \simeq 2B_E/5$ if the value h_{eff} of Planck constant was much larger than h, $h_{eff}/h \sim 10^{13}$ was required in order to scale the energy of 10 Hz photon to that of a visible photon with frequency 10^{14} Hz.

2. The large value of h_{eff} suggests its identification as gravitational Planck constant $\hbar_{eff} = \hbar_{gr} = GMm/v_0$ given by Nottale's hypothesis [E2]. M denotes here Earth's mass and m the mass of the charged particle. This predicts that cyclotron frequencies in B_{end} correspond to dark photon energies in the visible and UV UV range. Most remarkably, the energies do not depend on the mass m of charged particles. This realizes the Equivalence Principle.

3. Visible-UV energy range is associated also with biophotons [I122, I71] discussed from TGD view point in [K20, K30]. This motivates the identification of biophotons as decay products of dark photons or possibly even dark N-photons resulting in $h_{eff} \to h$ transition. Dark photons or N-photons in this energy. Note that the Nottale hypothesis and the notion of a monopole magnetic flux tube make sense only in the TGD Universe.

4. $h_{eff}/h_0 = n$ is identifiable as a dimension of extension of rationals in number theoretic vision about TGD. n serves as a kind of IQ [L50, L51]. MB with $h_{eff} = h_{gr}$ corresponds to a rather high level of number theoretic complexity assignable to the MB of Earth as a quantum system. MB has a long scale of quantum coherence - even of the order of the scale of Earth - and is by its high "IQ" the natural "boss" and controls the dynamics of the ordinary biomatter. The molecular transitions induced by the transformations of dark cyclotron (3N-)photons would serve as a natural control tool of MB. The cyclotron condensates at MB can provicde quantized metabolic currencies in the absence of ATP machinery.

5. MB could generate already at few Kelvin temperatures various biologically important molecules by providing the metabolic energy for the formation of various valence bonds, such as carbon and peptide bonds and make possible the formation of lipids, DNA and RNA molecules and their polymers and also other basic organic molecule. Josephson radiation would in turn make possible the generation of proteins. Gravitation would be a key player in living systems and play an especially important role in the very early stage. The chemistry at ultralow temperatures would provide a direct experimental handle to the biophysics associated with MB.

15.3.5 What can one say about pre-tRNA?

What could be the prebiotic counterpart of tRNA?

1. DtRNA should have a molecular counterpart. The simplest guess is that it corresponds to an RNA type codon appearing in tRNA but somehow differing from it. Pre-tRNA could simply be the (AAC-H)3' end of the acceptor stem with AAC replaced with XYZ, where ZYZ denotes the codon part of tRNA. The addition of a hydrogen atom would relate pre-tRNA codon to ordinary RNA codon.

2. The bond energy for the pre-tRNA-AA pair as the energy of the ester bond would be about .5 eV, which corresponds to the metabolic energy quantum. Energy is therefore required to "charge" pre-tRNA. This requires metabolic energy and in the absence of ATP machinery, the energy should come from its precedessor. What prebiotic metabolism could be, will be discussed in the next section.

3. If this step works, the polymerization of tRNAs involving the transformation of the ester bond of pre-tRNA-AA to AA-AA peptide bond can occur spontaneously since the peptide bond has bond energy of order .1 eV. This would give rise to polypeptides. This process would be like a translation process for RNA but without an RNA template and therefore the outcome would be random. Also the RNA polymerization in this manner can be considered, now however the RNA-RNA valence bond has considerably higher bond energy.

4. If DRNA-RNA sequences are formed, they might be transformed to AA sequences by pre-translation process using pre-tRNA and resonance mechanism pairing DRNAs and dark counterparts of pre-tRNA-AA pairs. This would define the pre-translation process.

15.3.6   What could the prebiotic metabolic machinery be?

Metabolic machinery should have a prebiotic counterpart and have energy about .5 eV as metabolic energy quantum.

1. Could the splitting of a hydrogen bond with bond energy about .5 eV provide the energy needed in the formation of pre-tRNA-AA ester bond? IR photons are most effective in causing Pollack effect in water: could also they induce pre-tRNA-AA pairing? Both options would require the presence of water. In principle, the proposed mechanism could lead to a generation of water molecules (the energy of O-H bond is 4.81 eV) already at temperatures of few Kelvin.

2. Could MB somehow provide the metabolic energy quantum? Gravitational flux tubes are in a central role in the TGD inspired quantum biology. In [L112] it was observed that the gravitational binding energy of a nucleon in the gravitational field of Earth is .67 eV. This is somewhat larger than the metabolic energy quantum. A dark proton at a distance of about $.34R_E$, R_E Earth radius, from the surface of Earth has gravitational binding energy of .5 eV.

    The bond energy of the hydrogen bond is .5 eV. Could it correspond to the reduction of the gravitational binding energy due to the delocalization of a dark proton to a gravitational flux tube? Could the hydrogen bond become dark gravitational U-shaped monopole flux tube with $h_{eff} = h_{gr}$ so that the proton of the ordinary hydrogen bond would become gravitationally dark? the size scale of Earth would define the length scale of this flux tube. The flux tube could however still connect the same atoms.

    The transformation $h_{gr} \to h$ induces a dramatic shortening of the U-shaped gravitatonal flux tube loop and the gravitationally dark proton at the gravitational flux tube of MB transforms to an ordinary proton. This localization has interpretation as falling of the proton to the surface of Earth. Could the liberated energy have an interpretation as a ametabolic energy quantum?

    For a dark variant of hydrogen bond a gravitational flux tube between atoms should form a very long loop at which the gravitationally dark proton would reside. This kind of picture about dark flux tubes associated with gauge interactions has been suggested earlier. For instance, color flux tubes assignable to nuclear protons could extend to distances of the order of atomic size.

3. Phosphate is electronegative and forms hydrogen bonds. Phosphate ionization could be interpreted as a formation of a dark hydrogen bond. This would explain why phosphate ions have such a central role in metabolism. Effective ionization serves as the signature of the delocalization. Also other electronegative ions could play the role of phosphate and arsenite has done this in some bacterial systems (`https://cutt.ly/ZS1fznG`).

    The pre-biotic counterpart of metabolic machinery should have involved phosphate ions or some other electronegative ions forming dark hydrogen bonds.

4. Also the valence electrons of valence bonds can become dark by the lengthening of the valence bond to a U-shaped gravitational flux loop. For electrons the gravitational binding energy at height $.34R_E$ is about .25 meV and .5 meV for their Cooper pairsm. Note that .3 meV corresponds to the energy of photons in the microwave background.

   Could this define a second metabolic energy quantum important in scales by a factor $m_p/m_e \sim 2^{11}$ longer than nanoscale about 1 nm assignable to DNA. This is the length scale of the cell nucleus, microtubules and axons. Intriguingly, the minimal fluctuations of membrane potentials correspond to the so-called miniature end plate potentials .4 mV (https://cutt.ly/HSJIn76).

5. A gravitational valence bond, connecting a metal atom with an atom with an opposite valence, would lead to effective ionization of the metal atom. For instance, biologically important bosonic ions such as Ca^{++}, Mg^{++}, Fe^{++} and Zn++ associated with their oxides could correspond to effective ions like this.

   The signature would be a pairing with a neutral oxygen atom by a gravitational valence bond. I have introduced the notion of dark ion to explain the findings of Blackman [J28] and others and dark ion could correspond to this kind of pair. The original variant of the model assumed that the entire ion is dark, the later version assumed that the valence electron of free atom is dark, and the model consider here assumes that the valence bond is dark.

6. The effective ionization requires energy ΔE to compensate the increment of the gravitational potential energy given by $\Delta E = (\langle V_{gr}(R) \rangle - V_{gr}(R_E))$. Here $E_{gr}(R)$ is gravitational potential energy proton or electron, and R_E denotes the radius of Earth, and R is the distance of the point of flux tube from the center of Earth.

   This estimate neglects the kinetic energy of the dark particle at the flux loop. This assumption is not consistent with the localization near the top of the loop so that the estimate can serve only as a rough order of magnitude estimate.

7. The maximal value for ΔE for electron Cooper pair (dark Cooper pair is at infinite distance) corresponds to $V_{gr}(R_E) = .36$ meV to be compared with the energy scale .3 meV defined by the temperature of 3 K microwave background and to the value .4 meV of the miniature potential. This suggests that, in the case of the electron, the reduction of kinetic energy contributes more than 10 per cent to the ΔE.

   For a single dark proton one has $V_{gr}(R_E) \simeq .34$ eV, which is below the nominal value of the metabolic energy currency about .5 eV. If a single dark proton is involved, the reduction kinetic energy should contribute at least 32 per cent to ΔE.

   For a dark proton Cooper pair, one has the maximal value of $\Delta E = .68$ eV somewhat above the metabolic energy quantum. These findings support the idea that both proton and electron Cooper pairs give rise to metabolic energy quanta. The challenge would be to understand the mechanism for the formation of proton Cooper pairs.

8. The transformation of electrons and protons between ordinary and gravitationally dark states would be a key process of metabolism and biocatalysis. This conforms with the fact that proton and electron exchanges play a key role in biology. For instance, phosphorylation means that the receiving molecule gains phosphate, which can form gravitationally a dark hydrogen bond so that the system becomes metabolically active. This would correspond to the activation in bio-catalysis.

   DNA base pairs are connected by 2 (A-T) or 3 (G-C) hydrogen bonds. If these strands can appear as dark gravitational strands, the maximum of 2 (3) metabolic quanta could be liberated in A-T (G-C) pairs via a transformation to ordinary hydrogen bonds. Could this serve as a yet-unidentified source of metabolic energy in the replication and transcription?

9. In the same way, in a redox reaction, the electron donor is oxidized and the electron receiver is reduced. Reduced molecule gains the ability to have a gravitationally dark electron, and therefore becomes metabolically active in the electronic sense. Redox reaction would be the electronic counterpart for phosphorylation.

15.3.7 Could the metabolism of cilia and flagella rely on gravitationally dark electrons?

The recent work in TGD has led to considerable progress in the understanding of metabolism [L118] already discussed in the section **??**. The TGD based view about metabolism involves in an essential way quantum gravity.

The observation is that the gravitational binding energy of dark protons at Bohr orbits in Earth's gravitational field for $h_{eff} = h_{gr} = Gmm/v_0$ [E2] [K37, K38, K39, K40, K83] [L112, L107] can correspond to metabolic energy quantum in good approximation. The proposal is that the transformation of protons of hydrogen bonds possible for electronegative atoms and occurring at least for phosphate generates gravitationally dark protons. Their transformation would liberate metabolic energy quantum.

The prediction is that besides gravitationally dark protons also similar electrons define a metabolic energy currency relating to standard metabolic currency like cent to dollar. It is proposed that the electronic metabolic currency can be applied to the purely understood metabolism of cilia and flagella (`https://cutt.ly/WDkYZzx`). I attach the proposal below almost as such.

According to [I145] (`https://cutt.ly/EDkW2bu`) the recent measurements in sea urchin sperm (length ~ 50 μm long, diameter 0.2 μm) show that the energy consumed per flagellar beat corresponds to $\simeq 2 \times 10^5$ ATP molecules. There is no GTP inside cilium as in the case of axonal MTs (`https://cutt.ly/5DkYGB2`). It is difficult to understand how ATP machinery could provide the metabolic energy feed.

This motivates the question about whether local ciliary metabolism could rely on the transformation of valence electrons of some biologically important ions to dark electrons at the gravitational MB and vice versa? The reduction of h_{gr} for electrons would provide the metabolic energy related by a factor $m_e/m_p \simeq 2^{-11}$ to the ordinary. According [I145], about 4×10^8 gravitationally dark electrons would transform to ordinary ones in a single stroke of cilium.

Electronic metabolic energy quantum would relate like cent to dollar and make possible a more refined metabolism with fine tuning. Electronic metabolism could also be an essential part of ordinary metabolism.

Consider now the idea more quantitatively.

1. What could be the electronic analog of ATP machinery. All biologically important ions can be considered as effective ions with some valence electrons at gravitational MB. In particular, the bosonic ions Ca^{++}, Mg^{++}, Fe^{++} and Zn^{++} could have Bose-Einstein condensates of gravitationally dark Cooper pairs at the gravitational MB.

   Ca^{++} waves play a key role in cellular biology, Fe^{++} is essential for oxygen based metabolism, and Mg^{++} and Zn^{++} are important in bio-catalysis: for instance, ATP must bind to Mg ions in order to become active.

2. What could be the mechanism transforming valence electrons to dark electrons? This should happen for positively charged biologically important ions, in particular for the bosonic ions Ca^{++}, Mg^{++}, Fe^{++} and Zn^{++}. The consumption of metabolic energy would correspond to a de-ionization of dark ion Ca^{++} and this might make it possible to test the proposal. For instance, Ca^{++} could accompany ciliary waves.

   Where could the energy for ionization come from?

1. This question is also encountered in the chemistry of electrolytes [L46]. It is very difficult to understand how the external electromagnetic potentials, which give rise to extremely weak electric fields in atomic scales, could lead to ionization. The acceleration of electrons in the electric field along dark flux tubes involves very small dissipation and can easily give rise to electron energies making ionization possible.

2. MTs have a longitudinal electric field which by the generalization of Maxwell's equations to many-sheeted space-time (in stationary situation potential difference is same for paths along different space-time sheets) gives rise to an electric field along the magnetic flux tubes. These flux tubes need not be gravitational.

By darkness, the dissipation rate is low. Could the acceleration along flux tubes, in particular MT flux tubes, lead to the ionization? Could the electret property of linear biomolecules quite generally serve for the purpose of generating electronic metabolic energy storages in this way?

3. Assuming opposite charges $\pm Z_{MT}$ at the ends of dark magnetic flux tube associated with the MT, one obtains a rough estimate. The length of the cilium is $L \leq .5 \times 10^{-4}$ m and its radius is $R \sim 2 \times 10^{-7}$ m. The estimate for the energy gained by a unit charge e as it travels through the ciliary MT is $E \sim Z_{MT} e^2 L/R^2 \simeq Z_{MT} \times 2.85$ eV. The valence electron energy for atomic number Z with principal quantum number n (giving the row of the Periodic Table) is $E \simeq (Z/n)^2 \times 13.6$ eV. The ionization condition would be $Z_{MT} \geq (Z^2/n^2) \times 13.6/2.85$. For the double ionization in the case of Ca^{++} with $Z = 20$ and $n = 3$ this would give $Z_{MT} \geq 212$.

15.3.8 Quantum gravitation in TGD inspired quantum biology

The theory of Penrose and Hameroff [J82] assigns to microtubules quantum gravity in Planck length scale. In the TGD Universe, one does just the opposite. The hierarchy of effective Planck constants assigns to quantum gravitation quantum coherence scale even in the scales of astrophysical objects.

The notion of gravitational magnetic body

The proposed picture allows us to reconsider a long-standing question relating to the notion of MB with an onion-like layered structure. What could this sentence mean quantitatively?

1. The 4-surfaces X^4 with 1-D CP_2 projection and 3-D M^4 projection having 2-D membrane as E^3 projection are good candidates for various membrane objects in TGD Universe [L113]. The E^3 projection is not a minimal surface although X^4 is, and this possible if the 1-D CP_2 projection is dynamical. The flux tubes of MB should be assignable to kind of membrane-like surface.

2. The gravitational MB could be a layered structure containing the Bohr orbits with Bohr radii $r_n \propto n^2$ of particles in the gravitational field of Earth. Particles with different masses would concentrate at the same orbits. One would have the shell structure of the ordinary atom. This notion generalizes also to other interactions and for them the values of h_{eff} would be much smaller.

3. Flux sheets with a cylindrical rotational symmetry containing the orbits can be considered. These surfaces should be realized as preferred extremals of the action and should be minimal surfaces in $H = M^4 \times CP_2$. As closed surfaces they cannot define minimal surfaces of the Euclidean 3-space E^3. Indeed, soap bubbles are not minimal surfaces but require a constant pressure difference between interior and exterior. The analog of pressure difference would be non-trivial and dynamic 1-D projection of 4-D surface to CP_2 [L113]. The liberation of metabolic energy quantum would be analogous to a transition of hydrogen atom to a lower energy state.

Cell membrane, nerve pulse and quantum gravitation

This picture makes it possible to formulate a more precise view about the model of cell membrane as a generalized Josephson junction for which the generalized Josephson energy for charge Ze is the sum $E_J = ZeV + \Delta E_c$ of ordinary Josephson energy ZeV and difference ΔE_c of dark cyclotron energies for the flux tubes at the two sides of the cell membrane having in general different strengths of magnetic field.

The model requires large h_{eff} in order that Josephson frequencies can correspond to frequencies in the EEG range. This justifies the assumption that dark ions have $h_{eff} = h_{gr}$. The ionization would be effective and caused by the transformation of protons of hydrogen bonds and valence electrons to dark charge carriers at the gravitational flux tubes.

The physical meaning of the criticality against the generation of nerve pulse for a critical membrane potential $eV_{cr} \simeq .05$ eV has remained open.

1. Since voltage gives rise to negative potential energy, it seems clear that there must be positive contribution to the energy and this could come from the reduction ΔE_{gr} of the gravitational potential energy due to the positive *resp.* effective ionization of atoms of metal atoms *resp.* electronegative atoms with hydrogen bonds.

   The reduction of the gravitational potential energy for electrons is fraction m_e/m_p from that for protons so that protonic contribution should dominate in the reduction of gravitational potential energy if dark electrons and protons correspond to the same shell of gravitational atom. The first guess is that the energy shell and thus the distance from the Earth's surface is the same.

   The parametrization of the reduction of the gravitational energy per atom and for the difference ΔE_c of cyclotron energies should in the standard picture correspond to a thermodynamical formulation using chemical potentials to fix the ion concentrations. The water has very special thermodynamic properties in the range between freezing and boiling points and anomalies are largest near physiological temperatures. This would be due to the presence of dark hydrogen bonds, which supports the view that the number of dark protons and electrons depends on temperature.

2. In the first approximation the negative Coulombic interaction energy for the cell membrane is given by $E_{Coul} = -Q_{tot}eV = -\sum_i N_i(out)Z_i eV$, where N_i is the number effective ions with charge $Z_i e$. The contribution of positive charges is negative since V corresponds to a negative net charge for the cell. The situation is stable for $|E_{Coul}| \geq |E_{Coul,cr}| = N_p\Delta E_{gr}$. The system becomes critical at $Q_{tot}eV_{cr} = N_p\Delta E_{gr}$. The value of the critical potential energy is given by $eV_{cr} = N_p\Delta E_{gr}/Q_{tot}$ and is roughly constant for a given neuron. This suggests that the ratio N_p/Q_{tot} characterizes the cell.

   Neurons and ordinary cells could differ in that ordinary cells are either subcritical or so overcritical that nerve pulses do not occur. Subcriticality looks the more plausible option. The emergence of the nervous system would mean the discovery of quantum criticality as a control tool of MB.

3. In the generation of the nerve pulse the dark protons and electrons become ordinary ones in the reduction $h_{gr} \to h_{eff} \leq\leq h_{gr}$ for them and the membrane potential changes sign. In ZEO this transition could correspond to BSFR inducing time reversal and change of membrane potential. The second BSFR would bring back the original situation and membrane potential would return to the over-critical value.

Microtubules and quantum gravitation

In the TGD Universe quantum gravitation would be associated with the cell membrane, in particular neuronal membrane. Quantum gravitation has been speculatively assigned with microtubules (MTs) rather than cellular or neuronal membranes. What is the situation in TGD?

1. Axonal MTss are highly critical systems, which continually change their lengths. The surface of MTs has one GDP per tubulin dimer and the ends of MT has GTPs so that there is a constant negative charge per unit length. The number of GTPs is larger at the second end so that there is an electric field along MT.

2. GTP$\leftrightarrow GDP$ process accompanies the variation of the length of the MT. The transformation of the protons assignable to the phosphate hydrogen bonds to gravitationally dark protons could be an essential element of the MT dynamics. The periods of increasing/decreasing MT length could be initiated by BSFR and would correspond to different arrows of time. The effective ionization affects the effective charge of the axonal interior and therefore of membrane potential. This suggests a strong correlation with the variation of axonal MT lengths and nerve pulse propagation.

   The propagation of nerve pulse through the myelinated sections of the axons, where ion transfer with cell exterior is not possible, is a mystery in the standard model. Without axonal MTs the nerve pulse propagation would not be possible. This could allow us to understand why various neuronal diseases involve a reduced MT stability [J44] (`https://cutt.ly/4DaF6qc`).

$$CEG \equiv C \ , \quad CD\sharp G \equiv Cm \ , \quad CD\sharp F\sharp \equiv C^o \ , \quad CEG\sharp \equiv Caug \ ,$$
$$CFG \equiv C4 \ , \quad CF\sharp G \equiv C4_+ \ , \quad CGG\sharp \equiv C6_- \ , \quad CGA \equiv C6 \ ,$$
$$CGB\flat \equiv C7 \ , \quad CGB \equiv Cmaj7 \ , \quad CGC\sharp \equiv C9_- \ , \quad CGD \equiv C9 \ . \tag{15.4.1}$$

Table 15.1: Notation of chords inspired by popular music notations.

15.4 Appendix: Tables of basic types of 3-chords for icosahedral harmonies

15.4.1 Icosahedral harmonies as Hamiltonian cycles

One can find the list of Hamiltonian cycles at `http://tinyurl.com/yacgzm9x`. The edge $\{1, 2\}$ is fixed and cycles are oriented so that there are 1024 of them. All of them are relevant from the point of music interpretation and the change of orientation corresponds to major-minor duality, albeit not in the simplest sense. Note that this duality does not affect the characteristics listed above.

The general following general results hold true as one can learn at `http://tinyurl.com/pmghcwd`. One can classify the cycles using their symmetries which can correspond to isometries of icosahedron leaving them fixed or to a reflection taking the vertex n at the cycle to vertex $12 - n$. This symmetry is not same as change of orientation which is purely internal operation and cannot change the cycle.

One can even find images of the cycles possessing symmetries at `http://tinyurl.com/y8ek7ak8` and deduce the triplets n and p characterizing them by visual inspection. Also one can write explicitly the 3-chords defined by the three kinds of faces. I have deduced the triplets n and the 3-chords defining the harmony by the inspection of the images. "Bio-harmony" $(4, 8, 8)$ forced by the model of extended genetic code involving also the 21st and 22nd amino-acids is of special interest.The classes of cycles with symmetries 6-fold rotational symmetry and two distinct reflection symmetries realize it.

Before continuing some terminology and notation is in order. Take C as the major key. Submediant or relative minor corresponds to Am, subdominant (sharp or flat) to F major (F) or Fminor (Fm), dominant to G. The notation for chords is such that quints correspond to subsequent notes in the chord. For 1-quint chords this means that first two notes define the quint.

Table 15.1 summarizes the notation inspired by the popular music notation. The basic difference is that the third is in most cases excluded so that the emotional character of the chord is not fixed.

Besides these notions it is convenient to introduce additional notations for various dissonant chords appearing as 0-quint chords.

$$CC\sharp D \equiv Cex1 \ , \quad CC\sharp D\sharp \equiv Cex2 \ , \quad CDD\sharp \equiv Cex3 \ , \quad CDE \equiv Cex4 \ ,$$
$$CD\sharp E \equiv Cex5 \ , \quad CC\sharp E \equiv Cex6 \ , \quad CDF\sharp \equiv Cex7 \ , \quad CDG\sharp \equiv Cex8 \ . $$
$$\tag{15.4.2}$$

Clearly, the sets {ex1}, {ex2, ex3}, {ex4, ex5, ex6}, {ex7}, {ex8}, corresponds to the span of 2, 3, 4, 6, 8 half notes for the chord.

The following summarizes the results. Note that $Cex7$ can be seen as part of $D7$ chord.

1. There are 6 collections of cycles without any symmetries containing 48 cycles each: these 48 cycle are mutually isometric so that one can say that there 6 different harmonies.

2. There is a collection with 6-fold rotational symmetry, 48/6=8 examples. $n = (2, 12, 6)$. The chords of this scale define 6-note scale involving only total steps. CDF and its 6 translates by integer number of steps define 6 1-quint chords. $CE\flat G$ (Cm) and its 6 translates (they obviously correspond to the 6-fold rotational symmetry) define also 6 1-quint chords. The reflection transforms these series to those defined by $GB\flat G$ and its translate and by FAC

(F major) and its translates. Impressionists like Debussy used 6-note scale of this kind. Half-octave shift is an exact symmetry. 1-chords lack the third so that one cannot assign to 3-chords any emotional quality. The extension to 4-chord can however bring either "happy" or "sad" quality. Clearly, these harmonies have "jazzy" character.

0-quint chords are $Faug \equiv FAC\sharp$ and $Gaug \equiv GHD\sharp$ are transformed to each other by both half-octave shift and inversion.

3. There are 2 collections with 2 distinct reflectional symmetries with 12=48/4 representatives in each. Half-octave scaling is a symmetry of both these scales as one might guess.

The first cycle (see **Fig. ??**) has $n = (0, 16, 4)$ so that there are no 0-quint chords which in general are dissonant. Second cycle (see **Fig. ??**) realizes $n = (4, 8, 8)$ bio-harmony and deserves some comments. It will be discussed in detail later.

   (a) The 8 2-quint chords consist of $B\flat FG \equiv B\flat 9$, C9, F9, G9 and their half-octave scalings. Clearly, the simple four-note scale appears here.

   (b) Using the popular notion introduced earlier, 1-quint chords consist of two 4-plets $Dmaj7$, $E9_-$, $A7$, $A6$ and $G\sharp maj7$, $B\flat 9_-$, $D\sharp 7$, $D\sharp 6$ related by half-octave shift. The harmony contains no "simple" major or minor chord and only the extension to tetra-hedral harmony can provide them. The same is true for the second bio-harmony.

   (c) The 4 0-quint chords are $Cex3 \equiv CDD\sharp$ and $Eex2 \equiv EFG$ and their half-octave scalings $F\sharp ex3 \equiv F\sharp G\sharp A$ and $B\flat ex2 \equiv B\flat BC\sharp G$.

4. There are 3 collections with Z_2 rotational symmetry with $48/2 = 24$ representatives in each. The triplets n are $(0, 16, 4)$ (see **Fig. ??**), $(2, 12, 6)$ (see **Fig. ??**), and $(4, 8, 8)$ (see **Fig. ??**).

All these harmonies are symmetric with respect to half-octave shift (tritonus), which obviously corresponds to the Z_2 rotation. Tritonus would not have been tolerated by catholic church! This symmetry characterizes all 3 harmonies. Basic 3-chords do not contain pure minor and major chords. The reflection of the scale does not leave the collection of chords invariant but it is not clear whether this corresponds only to a change of scale, probably not.

Consider the $(4, 8, 8)$ case (see **Fig. ??**).

   (a) The 8 2-quint chords appear as four-plet $H9, C\sharp 9, D\sharp 9, F9$ and its half octave shift (tritonus interval) acting as a symmetry of the harmony. 2-quint chords are always of type X^9 (note that the third is missing) but also 1-quint chord can be of form X^9 as explicit construction of chords demonstrates: I have denoted these 1-quint chords by symbol $X4$ (CDG is obviously equivalent with CDG).

   (b) Using the popular music notation introduced earlier, the 8 1-quint chords are $D7, Amaj7, A4_+, E7$ and their half-octave shifts $G\sharp 7, D\sharp 7, D\sharp 4_+, B\flat 7$.

No major and minor chords are included and only the extension to tetra-icosahedral harmony can provide them and also break the symmetry giving rise to well-defined key.

5. The four 0-quint chords appear in two types. $D\sharp ex2 \equiv D\sharp EF\sharp$ and its half-octave shift $Aex2 \equiv AB\flat C$ plus $Hex3 \equiv HC\sharp G$ and its half-octave shift $Fex3 \equiv FGC\sharp$. According to usual thinking these chords involve dissonances. This dissonance character is a rather general phenomenon for the harmonic loners and classical views about harmony would exclude them as asocial cases! In the case of maximally symmetric harmony the loners are diminished chords and thus not so dissonant. In some cases there are no 0-quint chords.

There are 5 collections of 20 chords with Z_2 reflection symmetry (see **Figs. ??, ??, ??, ??, ??**). The integer triplets n are $(2, 12, 6), (2, 12, 6), (4, 10, 6), (2, 12, 6), (2, 12, 6)$. Bio-harmony has a representative also in this class (see **Fig. ??**). The half-octave scaling symmetry is broken for these harmonies.

Some comments $(4, 8, 8)$ case are in order (see **Fig. ??**).

(n_0, n_1, n_2)	0-chords	1-chords	2-chords
(2, 12, 6)	$(Faug, Gaug)$	$(Cm, Dm, Em, F\sharp m, G\sharp m, B\flat m)$,	$(C9, D9, E9, F\sharp 9, G\sharp 9, B\flat 9)$.
		$(F6, G6, A6, B6, C\sharp 6, D\sharp 6)$.	

Table 15.2: Table gives various types of 3-chords for harmonies with Z_6 rotational symmetry. Note that half-octave shift is an exat symmetry. Note that $G^{aug} = CEG\sharp$, F^{aug} act as bridges between the groups related by half octave shift. The chords have been arranged so that they form orbits of Z_6. "Amino-acid chords" correspond to preferred chords at the orbits.

(n_0, n_1, n_2)	0-chords	1-chords	2-chords
(0, 16, 4)		$(D7, D6, G\sharp 7, G\sharp 6)$,	$(B\flat 9, B9, E9, F9)$.
		$(G4+, A9-, C\sharp 4+, D\sharp 9-)$,	
		$(Emaj7, Gmaj7, B\flat maj7, C\sharp maj7)$,	
		$(C9-, A9-, F\sharp 9-, D\sharp 9-)$.	
(4, 8, 8)	$(Cex3, Eex2, F\sharp ex3, B\flat ex2)$.	$(Dmaj7, E9-, A7, A6)$,	$(B\flat 9, F9, C9, G9)$.
		$(G\sharp maj7, B\flat 9-, D\sharp 7, D\sharp 6)$.	$(E9, B9, F\sharp 9, C\sharp 9)$.

Table 15.3: Table gives various types of 3-chords for the two harmonies with $Z_4 = Z_2^{rot} \times Z_2^{refl}$ symmetry. 4-plets represent the orbits. First cycle has no harmonic loners. Second cycle gives rise to bio-harmony (4, 8, 8) for which 0-quint chords are dissonant. Both cycles have Z_2 rotation symmetry acting as a vertical reflection symmetry in figures and realized also as half-octave shift so that 4-plets contains chords and their half-octave shifts. The genuine reflection symmetry acts as a horizontal reflection symmetry in figures. The cycles correspond to figures **??, ??**.

1. 2-quint chords appear as reflection related multiplets $C9, D9, H\sharp 9, D\sharp 9$ and $C\sharp 9, H9, F9, B\flat 9$.

2. 1-quint chords appear as symmetry related mutiplets $G, D7, Amaj7, E7$ and $C\sharp m, F\sharp 6, H6_-, E6$. Key G major and $C\sharp$ minor would be natural looking keys even without tetrahedral extension. For the mirror image $B\flat$ minor and E major would be the natural looking keys. For extension E major would be the key.

To sum up, half octave shift is a symmetry of all harmonies expected those having only Z_2 reflection symmetry, and fails thus also for the corresponding bio-harmonies. The tables below give list for the three types of 3-chords for the 11 harmonies possessing symmetries. A 3-chord with n quints is called n-quint chord. The harmonies are labelled by integer triplets (n_0, n_1, n_2), n_i gives the number of n-quint chords.

The reversal of the orientation for the cycle induces the transformation $C \leftrightarrow C$, $F\sharp \leftrightarrow F\sharp$, $H \leftrightarrow C\sharp$, $F \leftrightarrow G$, $D \leftrightarrow B\flat$, $E \leftrightarrow G\sharp$, $A \leftrightarrow D\sharp$ and produces a new scale with minor type chords mapped to major type chords and vice versa.

The standard notation of chords used in popular music is used. One must however remember that all 3-chords except those which are simple majors or minors lack the third so that their emotional tone remains uncharacterized. For instance, $C6$ does could be replaced with $Cm6$ and $G7$ with $Gm7$. The reader can check the chords by direct inspection of the figures. The convention used is that vertex number 1 in Hamiltonian cycle corresponds to C note.

15.4.2 Tables for the 3-chords of icosahedral harmonies

The following tables give the 3-chords of the icosahedral harmonies.

15.4.3 Illustrations of icosahedral Hamiltonian cycles with symmetries

The figures below illustrate the Hamiltonian cycles involved. Quite generally, the Z_n symmetry acts by a shift by $12/n$ quints along the cycle and the orbits of chords consist of at most n chords of same type as the reader is encouraged to verify.

$(\mathbf{n_0}, \mathbf{n_1}, \mathbf{n_2})$	0-chords	1-chords	2-chords
(0, 16, 4)		$(Em, B\flat m), (Cm, F\sharp m),$	$(D9, G\sharp 9),$
		$(G6, C\sharp 6), (A6, D\sharp 6),$	$(E9, B\flat 9).$
		$(D4+, G\sharp 4+), (B4+, F4+),$	
		$(Cmaj7, F\sharp maj7), (G6-, C\sharp 6-).$	
(2, 12, 6)	$(Aex4, D\sharp ex2).$	$(Am, D\sharp m), (G9-, C\sharp 9-),$	$(C9, F\sharp 9),$
		$(C4, F\sharp 4), (E4+, B\flat 4+),$	$(A9, D\sharp 9),$
		$(Dmaj7, G\sharp maj7),$	$(D9, G\sharp 9).$
		$(Bmaj7, Fmaj7).$	
(4, 8, 8)	$(Aex2, Hex8, D\sharp ex2, Fex8).$	$(D7, G\sharp 7), (Amaj7, D\sharp maj7),$	$(G9, C\sharp 9), (A9, D\sharp 9),$
		$(A4+, D\sharp 4+), (E7, B\flat 7).$	$(B9, F9), (E9, B\flat 9).$

Table 15.4: Table gives various types of 3-chords for harmonies with Z_2 rotation symmetry acting as half-octave shift. The doublets represent 2-chord orbits. The cycles correspond to figures **??**, **??**, and **??**.

$(\mathbf{n_0}, \mathbf{n_1}, \mathbf{n_2})$	0-chords	1-chords	2-chords
(2, 12, 6)	$(F\sharp ex3, Hex4),$	$(Am, D\sharp), (A6, D\sharp 7),$	$(C9, F9), (B9, F\sharp 9),$
		$(D7, B\flat 6), (G6-, Fmaj7),$	$(E9, C\sharp 9).$
		$(D4+, B\flat 9-), (E9-, G\sharp 4+),$	
(2, 12, 6)	$(Dex4, Hex4).$	$(F, Fm), (C6-, B\flat maj7),$	$(C9, D\sharp 9),$
		$(D7, G\sharp 6), (Gmaj7, D\sharp 6-).$	$(D\sharp 9, C\sharp 9),$
		$(C\sharp 4-, A4+), (E4+, F\sharp 6).$	$(E9, B9).$
(4, 8, 8)	$(Fex1, D\sharp ex3, G\sharp ex1, Aex2).$	$(E7, E6), (Amaj7, B9-),$	$(D9, B9), (C9, C\sharp 9),$
		$(G, C\sharp m), (D7, F\sharp 6).$	$(F9, G\sharp 9), (D\sharp 9, B\flat 9).$
(2, 12, 6)	$(Hex3, Eex7).$	$(D7, G\sharp 6), (G, D\sharp m),$	$(C9, D\sharp 9),$
		$(F, Fm), (C6-, B\flat maj7),$	$(D9, C\sharp 9),$
		$(A9-, C\sharp 4+), (E7, F\sharp 6).$	$(E9, B9).$
(2, 12, 6)	$(F\sharp ex2, Fex3).$	$(F, B\flat m), (C7, G\sharp 6),$	$(B\flat 9, D\sharp 9),$
		$(Amaj7, B9-), (E6, E7),$	$(C9, C\sharp 9),$
		$(G, C\sharp m), (D7, B6).$	$(D9, H9).$

Table 15.5: Table gives various types of 3-chords for harmonies with single reflection symmetry. The cycles correspond to figures **??**, **??**, **??**, **??**, **??**.
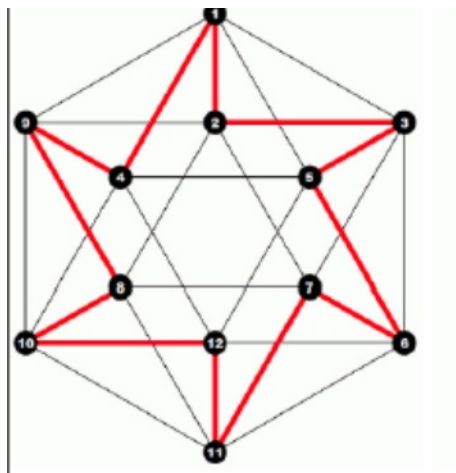
Figure 15.1: $(n_0, n_1, n_2) = (2, 12, 6)$ Hamiltonian cycle with 6-fold rotation symmetry acting shifts generated by a shift of 2 quints.
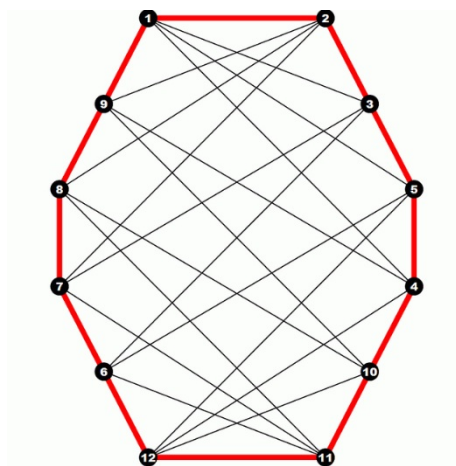
Figure 15.2: $(n_0, n_1, n_2) = (0, 16, 4)$ Hamiltonian cycle with 4 reflection symmetries generated by reflections in vertical and horizontal directions.
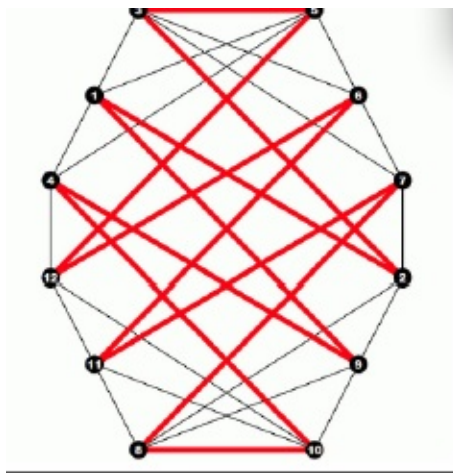
Figure 15.3: $(n_0, n_1, n_2) = (4, 8, 8)$ Hamiltonian cycle with 4 reflection symmetries.
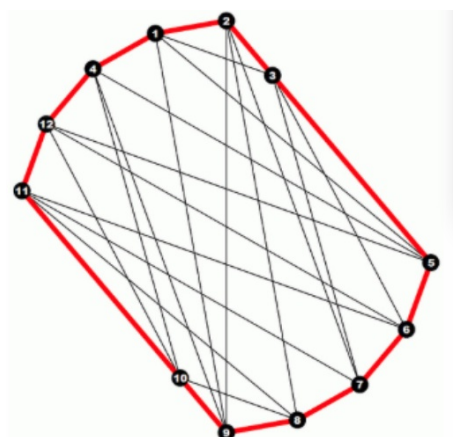
Figure 15.4: $(n_0, n_1, n_2) = (0, 16, 4)$ Hamiltonian cycle with 2-fold rotational symmetry realized as 6-quint shift along the cycle.
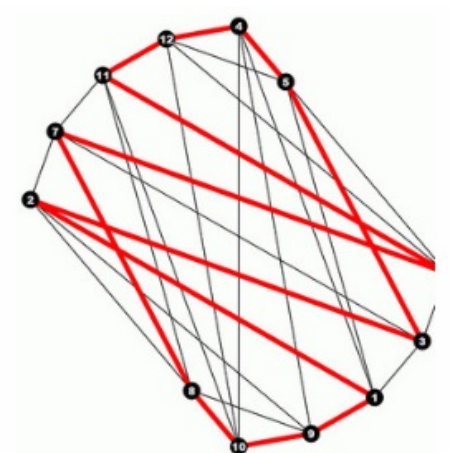
Figure 15.5: $(n_0, n_1, n_2) = (2, 12, 6)$ Hamiltonian cycle with 2-fold rotation symmetry.
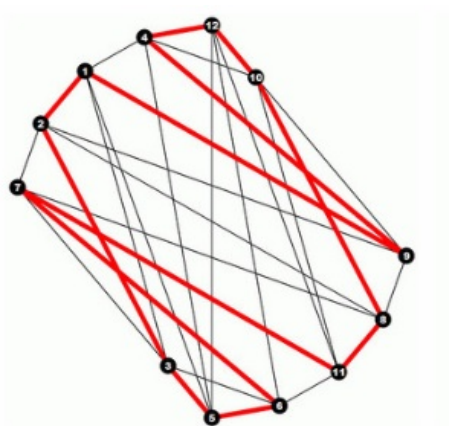
Figure 15.6: $(n_0, n_1, n_2) = (4, 8, 8)$ Hamiltonian cycle with 2-fold rotation symmetry.
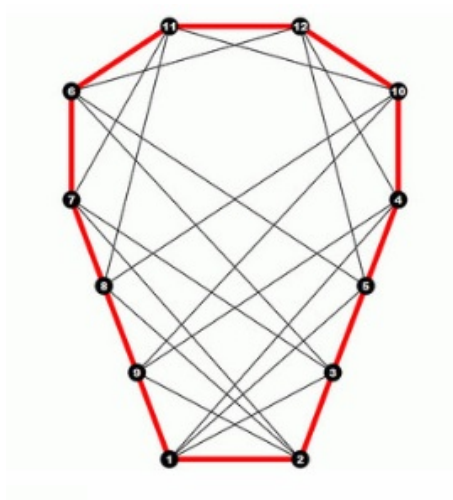
Figure 15.7: $(n_0, n_1, n_2) = (2, 12, 6)$ Hamiltonian cycle with 2-fold reflection symmetry realized as horizontal reflection
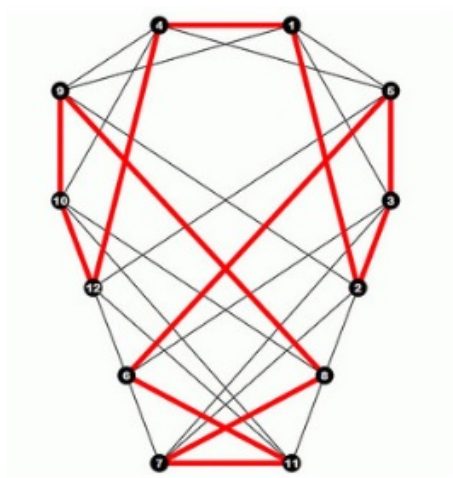
Figure 15.8: $(n_0, n_1, n_2) = (2, 12, 6)$ Hamiltonian cycle with 2-fold reflection symmetry.
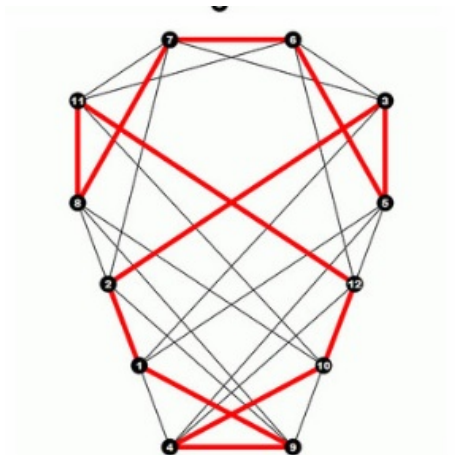
Figure 15.9: $(n_0, n_1, n_2) = (4, 8, 8)$ Hamiltonian cycle with 2-fold reflection symmetry.
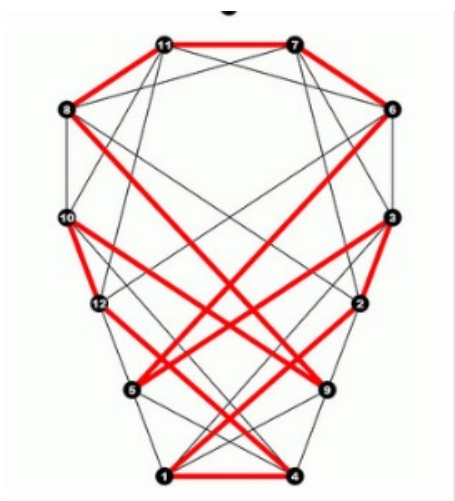
Figure 15.10: $(n_0, n_1, n_2) = (2, 12, 6)$ Hamiltonian cycle with 2-fold reflection symmetry.
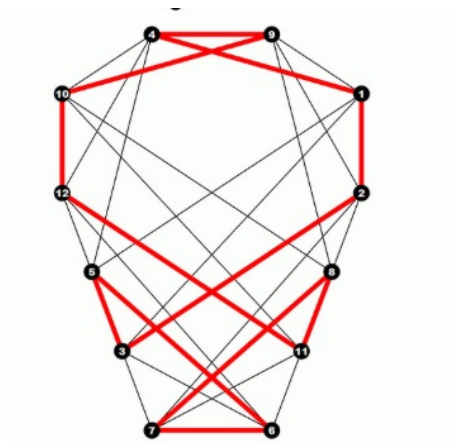
Figure 15.11: $(n_0, n_1, n_2) = (2, 12, 6)$ Hamiltonian cycle with 2-fold reflection symmetry.

Chapter i

Appendix

A-1   Introduction

Originally this appendix was meant to be a purely technical summary of basic facts but in its recent form it tries to briefly summarize those basic visions about TGD which I dare to regarded stabilized. I have added illustrations making it easier to build mental images about what is involved and represented briefly the key arguments. This chapter is hoped to help the reader to get fast grasp about the concepts of TGD.

The basic properties of embedding space and related spaces are discussed and the relationship of CP_2 to the standard model is summarized. The basic vision is simple: the geometry of the embedding space $H = M^4 \times CP_2$ geometrizes standard model symmetries and quantum numbers. The assumption that space-time surfaces are basic objects, brings in dynamics as dynamics of 3-D surfaces based on the induced geometry. Second quantization of free spinor fields of H induces quantization at the level of H, which means a dramatic simplification.

The notions of induction of metric and spinor connection, and of spinor structure are discussed. Many-sheeted space-time and related notions such as topological field quantization and the relationship many-sheeted space-time to that of GRT space-time are discussed as well as the recent view about induced spinor fields and the emergence of fermionic strings. Also the relationship to string models is discussed briefly.

Various topics related to p-adic numbers are summarized with a brief definition of p-adic manifold and the idea about generalization of the number concept by gluing real and p-adic number fields to a larger book like structure analogous to adele [L50, L51]. In the recent view of quantum TGD [L124], both notions reduce to physics as number theory vision, which relies on $M^8 - H$ duality [L96, L97] and is complementary to the physics as geometry vision.

Zero energy ontology (ZEO) [L92] [K126] has become a central part of quantum TGD and leads to a TGD inspired theory of consciousness as a generalization of quantum measurement theory having quantum biology as an application. Also these aspects of TGD are briefly discussed.

A-2   Embedding space $M^4 \times CP_2$

Space-times are regarded as 4-surfaces in $H = M^4 \times CP_2$ the Cartesian product of empty Minkowski space - the space-time of special relativity - and compact 4-D space CP_2 with size scale of order 10^4 Planck lengths. One can say that embedding space is obtained by replacing each point m of empty Minkowski space with 4-D tiny CP_2. The space-time of general relativity is replaced by a 4-D surface in H which has very complex topology. The notion of many-sheeted space-time gives an idea about what is involved.

Fig. 1. Embedding space $H = M^4 \times CP_2$ as Cartesian product of Minkowski space M^4 and complex projective space CP_2. `http://tgdtheory.fi/appfigures/Hoo.jpg`

Denote by M_+^4 and M_-^4 the future and past directed lightcones of M^4. Denote their intersection, which is not unique, by CD. In zero energy ontology (ZEO) [L92, L110] [K126] causal

diamond (CD) is defined as cartesian product $CD \times CP_2$. Often I use CD to refer just to $CD \times CP_2$ since CP_2 factor is relevant from the point of view of ZEO.

Fig. 2. Future and past light-cones M^4_+ and M^4_-. Causal diamonds (CD) are defined as their intersections. `http://tgdtheory.fi/appfigures/futurepast.jpg`

Fig. 3. Causal diamond (CD) is highly analogous to Penrose diagram but simpler. `http://tgdtheory.fi/appfigures/penrose.jpg`

A rather recent discovery was that CP_2 is the only compact 4-manifold with Euclidian signature of metric allowing twistor space with Kähler structure. M^4 is in turn is the only 4-D space with Minkowskian signature of metric allowing twistor space with Kähler structure [A17] so that $H = M^4 \times CP_2$ is twistorially unique.

One can loosely say that quantum states in a given sector of "world of classical worlds" (WCW) are superpositions of space-time surfaces inside CDs and that positive and negative energy parts of zero energy states are localized and past and future boundaries of CDs. CDs form a hierarchy. One can have CDs within CDs and CDs can also overlap. The size of CD is characterized by the proper time distance between its two tips. One can perform both translations and also Lorentz boosts of CD leaving either boundary invariant. Therefore one can assign to CDs a moduli space and speak about wave function in this moduli space.

In number theoretic approach it is natural to restrict the allowed Lorentz boosts to some discrete subgroup of Lorentz group and also the distances between the tips of CDs to multiples of CP_2 radius defined by the length of its geodesic. Therefore the moduli space of CDs discretizes. The quantization of cosmic recession velocities for which there are indications, could relate to this quantization.

A-2.1 Basic facts about CP_2

CP_2 as a four-manifold is very special. The following arguments demonstrate that it codes for the symmetries of standard models via its isometries and holonomies.

CP_2 as a manifold

CP_2, the complex projective space of two complex dimensions, is obtained by identifying the points of complex 3-space C^3 under the projective equivalence

$$(z^1, z^2, z^3) \equiv \lambda(z^1, z^2, z^3) \ . \tag{A-2.1}$$

Here λ is any non-zero complex number. Note that CP_2 can be also regarded as the coset space $SU(3)/U(2)$. The pair z^i/z^j for fixed j and $z^i \neq 0$ defines a complex coordinate chart for CP_2. As j runs from 1 to 3 one obtains an atlas of three coordinate charts covering CP_2, the charts being holomorphically related to each other (e.g. CP_2 is a complex manifold). The points $z^3 \neq 0$ form a subset of CP_2 homoeomorphic to R^4 and the points with $z^3 = 0$ a set homeomorphic to S^2. Therefore CP_2 is obtained by "adding the 2-sphere at infinity to R^4".

Besides the standard complex coordinates $\xi^i = z^i/z^3$, $i = 1, 2$ the coordinates of Eguchi and Freund [A13] will be used and their relation to the complex coordinates is given by

$$\begin{aligned} \xi^1 &= z + it \ , \\ \xi^2 &= x + iy \ . \end{aligned} \tag{A-2.2}$$

These are related to the "spherical coordinates" via the equations

$$\begin{aligned} \xi^1 &= r \exp(i\frac{(\Psi + \Phi)}{2})\cos(\frac{\Theta}{2}) \ , \\ \xi^2 &= r \exp(i\frac{(\Psi - \Phi)}{2})\sin(\frac{\Theta}{2}) \ . \end{aligned} \tag{A-2.3}$$

The ranges of the variables r, Θ, Φ, Ψ are $[0, \infty], [0, \pi], [0, 4\pi], [0, 2\pi]$ respectively.

Considered as a real four-manifold CP_2 is compact and simply connected, with Euler number Euler number 3, Pontryagin number 3 and second $b = 1$.

Fig. 4. CP_2 as manifold. `http://tgdtheory.fi/appfigures/cp2.jpg`

Metric and Kähler structure of CP_2

In order to obtain a natural metric for CP_2, observe that CP_2 can be thought of as a set of the orbits of the isometries $z^i \rightarrow exp(i\alpha)z^i$ on the sphere S^5: $\sum z^i \bar{z}^i = R^2$. The metric of CP_2 is obtained by projecting the metric of S^5 orthogonally to the orbits of the isometries. Therefore the distance between the points of CP_2 is that between the representative orbits on S^5.

The line element has the following form in the complex coordinates

$$ds^2 \quad = \quad g_{a\bar{b}} d\xi^a d\bar{\xi}^b \ , \tag{A-2.4}$$

where the Hermitian, in fact Kähler metric $g_{a\bar{b}}$ is defined by

$$g_{a\bar{b}} \quad = \quad R^2 \partial_a \partial_{\bar{b}} K \ , \tag{A-2.5}$$

where the function K, Kähler function, is defined as

$$
\begin{aligned}
K \quad &= \quad log(F) \ , \\
F \quad &= \quad 1 + r^2 \ .
\end{aligned}
\tag{A-2.6}
$$

The Kähler function for S^2 has the same form. It gives the S^2 metric $dzd\bar{z}/(1+r^2)^2$ related to its standard form in spherical coordinates by the coordinate transformation $(r, \phi) = (tan(\theta/2), \phi)$.

The representation of the CP_2 metric is deducible from S^5 metric is obtained by putting the angle coordinate of a geodesic sphere constant in it and is given

$$\frac{ds^2}{R^2} \quad = \quad \frac{(dr^2 + r^2 \sigma_3^2)}{F^2} + \frac{r^2(\sigma_1^2 + \sigma_2^2)}{F} \ , \tag{A-2.7}$$

where the quantities σ_i are defined as

$$
\begin{aligned}
r^2 \sigma_1 \quad &= \quad Im(\xi^1 d\xi^2 - \xi^2 d\xi^1) \ , \\
r^2 \sigma_2 \quad &= \quad -Re(\xi^1 d\xi^2 - \xi^2 d\xi^1) \ , \\
r^2 \sigma_3 \quad &= \quad -Im(\xi^1 d\bar{\xi}^1 + \xi^2 d\bar{\xi}^2) \ .
\end{aligned}
\tag{A-2.8}
$$

R denotes the radius of the geodesic circle of CP_2. The vierbein forms, which satisfy the defining relation

$$s_{kl} \quad = \quad R^2 \sum_A e_k^A e_l^A \ , \tag{A-2.9}$$

are given by

$$
\begin{aligned}
e^0 \quad &= \quad \frac{dr}{F} \ , \quad & e^1 \quad &= \quad \frac{r\sigma_1}{\sqrt{F}} \ , \\
e^2 \quad &= \quad \frac{r\sigma_2}{\sqrt{F}} \ , \quad & e^3 \quad &= \quad \frac{r\sigma_3}{F} \ .
\end{aligned}
\tag{A-2.10}
$$

The explicit representations of vierbein vectors are given by

$$
\begin{aligned}
e^0 &= \frac{dr}{F} \ , & e^1 &= \frac{r(sin\Theta cos\Psi d\Phi + sin\Psi d\Theta)}{2\sqrt{F}} \ , \\
e^2 &= \frac{r(sin\Theta sin\Psi d\Phi - cos\Psi d\Theta)}{2\sqrt{F}} \ , & e^3 &= \frac{r(d\Psi + cos\Theta d\Phi)}{2F} \ .
\end{aligned}
$$

$$(A-2.11)$$

The explicit representation of the line element is given by the expression

$$
ds^2/R^2 \quad = \quad \frac{dr^2}{F^2} + \frac{r^2}{4F^2}(d\Psi + cos\Theta d\Phi)^2 + \frac{r^2}{4F}(d\Theta^2 + sin^2\Theta d\Phi^2) \ .
$$

$$(A-2.12)$$

From this expression one finds that at coordinate infinity $r = \infty$ line element reduces to $\frac{r^2}{4F}(d\Theta^2 + sin^2\Theta d\Phi^2)$ of S^2 meaning that 3-sphere degenerates metrically to 2-sphere and one can say that CP_2 is obtained by adding to R^4 a 2-sphere at infinity.

The vierbein connection satisfying the defining relation

$$
de^A \quad = \quad -V_B^A \wedge e^B \ ,
$$

$$(A-2.13)$$

is given by

$$
\begin{aligned}
V_{01} &= -\frac{e^1}{r} \ , & V_{23} &= \frac{e^1}{r} \ , \\
V_{02} &= -\frac{e^2}{r} \ , & V_{31} &= \frac{e^2}{r} \ , \\
V_{03} &= (r - \frac{1}{r})e^3 \ , & V_{12} &= (2r + \frac{1}{r})e^3 \ .
\end{aligned}
$$

$$(A-2.14)$$

The representation of the covariantly constant curvature tensor is given by

$$
\begin{aligned}
R_{01} &= e^0 \wedge e^1 - e^2 \wedge e^3 \ , & R_{23} &= e^0 \wedge e^1 - e^2 \wedge e^3 \ , \\
R_{02} &= e^0 \wedge e^2 - e^3 \wedge e^1 \ , & R_{31} &= -e^0 \wedge e^2 + e^3 \wedge e^1 \ , \\
R_{03} &= 4e^0 \wedge e^3 + 2e^1 \wedge e^2 \ , & R_{12} &= 2e^0 \wedge e^3 + 4e^1 \wedge e^2 \ .
\end{aligned}
$$

$$(A-2.15)$$

Metric defines a real, covariantly constant, and therefore closed 2-form J

$$
J \quad = \quad -is_{a\bar{b}}d\xi^a d\bar{\xi}^b \ ,
$$

$$(A-2.16)$$

the so called Kähler form. Kähler form J defines in CP_2 a symplectic structure because it satisfies the condition

$$
J^k_{\ r}J^{rl} \quad = \quad -s^{kl} \ .
$$

$$(A-2.17)$$

The condition states that J and g give representations of real unit and imaginary units related by the formula $i^2 = -1$.

Kähler form is expressible locally in terms of Kähler gauge potential

$$
J \quad = \quad dB \ ,
$$

$$(A-2.18)$$

where B is the so called Kähler potential, which is not defined globally since J describes homological magnetic monopole.

$dJ = ddB = 0$ gives the topological half of Maxwell equations (vanishing of magnetic charges and Faraday's induction law) and self-duality $*J = J$ reduces the remaining equations to $dJ = 0$. Hence the Kähler form can be regarded as a curvature form of a $U(1)$ gauge potential B carrying a magnetic charge of unit $1/2g$ (g denotes the gauge coupling).

The magnetic flux of J through a 2-surface in CP_2 is proportional to its homology equivalence class, which is integer valued. The explicit representations of J and B are given by

$$
\begin{aligned}
B &= 2re^3 \;, \\
J &= 2(e^0 \wedge e^3 + e^1 \wedge e^2) = \frac{r}{F^2} dr \wedge (d\Psi + cos\Theta d\Phi) + \frac{r^2}{2F} sin\Theta d\Theta \wedge d\Phi \;.
\end{aligned}
\tag{A-2.19}
$$

The vierbein curvature form and Kähler form are covariantly constant and have in the complex coordinates only components of type (1, 1).

Useful coordinates for CP_2 are the so called canonical (or symplectic or Darboux) coordinates in which the Kähler potential and Kähler form have very simple expressions

$$
\begin{aligned}
B &= \sum_{k=1,2} P_k dQ_k \;, \\
J &= \sum_{k=1,2} dP_k \wedge dQ_k \;.
\end{aligned}
\tag{A-2.20}
$$

The relationship of the canonical coordinates to the "spherical" coordinates is given by the equations

$$
\begin{aligned}
P_1 &= -\frac{1}{1+r^2} \;, \\
P_2 &= -\frac{r^2 cos\Theta}{2(1+r^2)} \;, \\
Q_1 &= \Psi \;, \\
Q_2 &= \Phi \;.
\end{aligned}
\tag{A-2.21}
$$

Spinors In CP_2

CP_2 doesn't allow spinor structure in the conventional sense [A11]. However, the coupling of the spinors to a half odd multiple of the Kähler potential leads to a respectable spinor structure. Because the delicacies associated with the spinor structure of CP_2 play a fundamental role in TGD, the arguments of Hawking are repeated here.

To see how the space can fail to have an ordinary spinor structure consider the parallel transport of the vierbein in a simply connected space M. The parallel propagation around a closed curve with a base point x leads to a rotated vierbein at x: $e^A = R^A_B e^B$ and one can associate to each closed path an element of $SO(4)$.

Consider now a one-parameter family of closed curves $\gamma(v) : v \in (0,1)$ with the same base point x and $\gamma(0)$ and $\gamma(1)$ trivial paths. Clearly these paths define a sphere S^2 in M and the element $R^A_B(v)$ defines a closed path in $SO(4)$. When the sphere S^2 is contractible to a point e.g., homologically trivial, the path in $SO(4)$ is also contractible to a point and therefore represents a trivial element of the homotopy group $\Pi_1(SO(4)) = Z_2$.

For a homologically nontrivial 2-surface S^2 the associated path in $SO(4)$ can be homotopically nontrivial and therefore corresponds to a nonclosed path in the covering group Spin(4) (leading from the matrix 1 to -1 in the matrix representation). Assume this is the case.

Assume now that the space allows spinor structure. Then one can parallel propagate also spinors and by the above construction associate a closed path of Spin(4) to the surface S^2. Now, however this path corresponds to a lift of the corresponding $SO(4)$ path and cannot be closed. Thus one ends up with a contradiction.

From the preceding argument it is clear that one could compensate the non-allowed -1-factor associated with the parallel transport of the spinor around the sphere S^2 by coupling it to a gauge potential in such a way that in the parallel transport the gauge potential introduces a compensating -1-factor. For a $U(1)$ gauge potential this factor is given by the exponential

$exp(i2\Phi)$, where Φ is the magnetic flux through the surface. This factor has the value -1 provided the $U(1)$ potential carries half odd multiple of Dirac charge $1/2g$. In case of CP_2 the required gauge potential is half odd multiple of the Kähler potential B defined previously. In the case of $M^4 \times CP_2$ one can in addition couple the spinor components with different chiralities independently to an odd multiple of $B/2$.

Geodesic sub-manifolds of CP_2

Geodesic sub-manifolds are defined as sub-manifolds having common geodesic lines with the embedding space. As a consequence the second fundamental form of the geodesic manifold vanishes, which means that the tangent vectors h_α^k (understood as vectors of H) are covariantly constant quantities with respect to the covariant derivative taking into account that the tangent vectors are vectors both with respect to H and X^4.

In [A21] a general characterization of the geodesic sub-manifolds for an arbitrary symmetric space G/H is given. Geodesic sub-manifolds are in 1-1-correspondence with the so called Lie triple systems of the Lie-algebra g of the group G. The Lie triple system t is defined as a subspace of g characterized by the closedness property with respect to double commutation

$$[X, [Y, Z]] \in t \text{ for } X, Y, Z \in t \ . \tag{A-2.22}$$

$SU(3)$ allows, besides geodesic lines, two nonequivalent (not isometry related) geodesic spheres. This is understood by observing that $SU(3)$ allows two nonequivalent $SU(2)$ algebras corresponding to subgroups $SO(3)$ (orthogonal 3×3 matrices) and the usual isospin group $SU(2)$. By taking any subset of two generators from these algebras, one obtains a Lie triple system and by exponentiating this system, one obtains a 2-dimensional geodesic sub-manifold of CP_2.

Standard representatives for the geodesic spheres of CP_2 are given by the equations

$$S_I^2 \ : \ \xi^1 = \bar{\xi}^2 \text{ or equivalently } (\Theta = \pi/2, \Psi = 0) \ ,$$

$$S_{II}^2 \ : \ \xi^1 = \xi^2 \text{ or equivalently } (\Theta = \pi/2, \Phi = 0) \ .$$

The non-equivalence of these sub-manifolds is clear from the fact that isometries act as holomorphic transformations in CP_2. The vanishing of the second fundamental form is also easy to verify. The first geodesic manifold is homologically trivial: in fact, the induced Kähler form vanishes identically for S_I^2. S_{II}^2 is homologically nontrivial and the flux of the Kähler form gives its homology equivalence class.

A-2.2 CP_2 geometry and Standard Model symmetries

Identification of the electro-weak couplings

The delicacies of the spinor structure of CP_2 make it a unique candidate for space S. First, the coupling of the spinors to the $U(1)$ gauge potential defined by the Kähler structure provides the missing $U(1)$ factor in the gauge group. Secondly, it is possible to couple different H-chiralities independently to a half odd multiple of the Kähler potential. Thus the hopes of obtaining a correct spectrum for the electromagnetic charge are considerable. In the following it will be demonstrated that the couplings of the induced spinor connection are indeed those of the GWS model [B19] and in particular that the right handed neutrinos decouple completely from the electro-weak interactions.

To begin with, recall that the space H allows to define three different chiralities for spinors. Spinors with fixed H-chirality $e = \pm 1$, CP_2-chirality l, r and M^4-chirality L, R are defined by the condition

$$\begin{aligned} \Gamma \Psi &= e\Psi \ , \\ e &= \pm 1 \ , \end{aligned} \tag{A-2.23}$$

where Γ denotes the matrix $\Gamma_9 = \gamma_5 \otimes \gamma_5$, $1 \otimes \gamma_5$ and $\gamma_5 \otimes 1$ respectively. Clearly, for a fixed H-chirality CP_2- and M^4-chiralities are correlated.

The spinors with H-chirality $e = \pm 1$ can be identified as quark and lepton like spinors respectively. The separate conservation of baryon and lepton numbers can be understood as a consequence of generalized chiral invariance if this identification is accepted. For the spinors with a definite H-chirality one can identify the vielbein group of CP_2 as the electro-weak group: $SO(4)$ having as its covering group $SU(2)_L \times SU(2)_R$.

The covariant derivatives are defined by the spinorial connection

$$A \quad = \quad V + \frac{B}{2}(n_+ 1_+ + n_- 1_-) \ . \tag{A-2.24}$$

Here V and B denote the projections of the vielbein and Kähler gauge potentials respectively and $1_{+(-)}$ projects to the spinor H-chirality $+(-)$. The integers $n_\pm$ are odd from the requirement of a respectable spinor structure.

The explicit representation of the vielbein connection V and of B are given by the equations

$$
\begin{array}{llll}
V_{01} & = & -\frac{e^1}{r} \ , & V_{23} & = & \frac{e^1}{r} \ , \\
V_{02} & = & -\frac{e^2}{r} \ , & V_{31} & = & \frac{e^2}{r} \ , \\
V_{03} & = & (r - \frac{1}{r})e^3 \ , & V_{12} & = & (2r + \frac{1}{r})e^3 \ ,
\end{array}
\tag{A-2.25}
$$

and

$$B \quad = \quad 2re^3 \ , \tag{A-2.26}$$

respectively. The explicit representation of the vielbein is not needed here.

Let us first show that the charged part of the spinor connection couples purely left handedly. Identifying Σ_3^0 and Σ_2^1 as the diagonal (neutral) Lie-algebra generators of $SO(4)$, one finds that the charged part of the spinor connection is given by

$$A_{ch} \quad = \quad 2V_{23}I_L^1 + 2V_{13}I_L^2 \ , \tag{A-2.27}$$

where one have defined

$$
\begin{array}{lll}
I_L^1 & = & \frac{(\Sigma_{01} - \Sigma_{23})}{2} \ , \\[2mm]
I_L^2 & = & \frac{(\Sigma_{02} - \Sigma_{13})}{2} \ .
\end{array}
\tag{A-2.28}
$$

A_{ch} is clearly left handed so that one can perform the identification of the gauge potential as

$$W^\pm \quad = \quad \frac{2(e^1 \pm ie^2)}{r} \ , \tag{A-2.29}$$

where $W^\pm$ denotes the charged intermediate vector boson.

The covariantly constant curvature tensor is given by

$$
\begin{array}{l}
R_{01} = -R_{23} = e^0 \wedge e^1 - e^2 \wedge e^3 \ , \\
R_{02} = -R_{31} = e^0 \wedge e^2 - e^3 \wedge e^1 \ , \\
R_{03} = 4e^0 \wedge e^3 + 2e^1 \wedge e^2 \ , \\
R_{12} = 2e^0 \wedge e^3 + 4e^1 \wedge e^2 \ .
\end{array}
\tag{A-2.30}
$$

The charged part of the curvature tensor is left handed.

This is to be compared with the Weyl tensor, which defines a representation of quaternionic imaginary units.

$$
\begin{aligned}
W_{03} &= W_{12} \equiv 2I_3 = 2(e^0 \wedge e^3 + e^1 \wedge e^2) \;, \\
W_{01} &= W_{23} \equiv I_1 = -e^0 \wedge e^1 - e^2 \wedge e^3 \;, \\
W_{02} &= W_{31} \equiv I_2 = -e^0 \wedge e^2 - e^3 \wedge e^1 \;.
\end{aligned}
\tag{A-2.31}
$$

The charged part of the Weyl tensor is right-handed and that the relative sign of the two terms in the curvature tensor and Weyl tensor are opposite.

Consider next the identification of the neutral gauge bosons γ and Z^0 as appropriate linear combinations of the two functionally independent quantities

$$
\begin{aligned}
X &= r e^3 \;, \\
Y &= \frac{e^3}{r} \;,
\end{aligned}
\tag{A-2.32}
$$

appearing in the neutral part of the spinor connection. We show first that the mere requirement that photon couples vectorially implies the basic coupling structure of the GWS model leaving only the value of Weinberg angle undetermined.

To begin with let us define

$$
\begin{aligned}
\bar{\gamma} &= aX + bY \;, \\
\bar{Z}^0 &= cX + dY \;,
\end{aligned}
\tag{A-2.33}
$$

where the normalization condition

$$
ad - bc = 1 \;,
$$

is satisfied. The physical fields γ and Z^0 are related to $\bar{\gamma}$ and $\bar{Z}^0$ by simple normalization factors.

Expressing the neutral part of the spinor connection in term of these fields one obtains

$$
\begin{aligned}
A_{nc} &= [(c+d)2\Sigma_{03} + (2d-c)2\Sigma_{12} + d(n_+1_+ + n_-1_-)]\bar{\gamma} \\
&+ [(a-b)2\Sigma_{03} + (a-2b)2\Sigma_{12} - b(n_+1_+ + n_-1_-)]\bar{Z}^0 \;.
\end{aligned}
\tag{A-2.34}
$$

Identifying Σ_{12} and $\Sigma_{03} = 1 \times \gamma_5 \Sigma_{12}$ as vectorial and axial Lie-algebra generators, respectively, the requirement that γ couples vectorially leads to the condition

$$
c = -d \;.
\tag{A-2.35}
$$

Using this result plus previous equations, one obtains for the neutral part of the connection the expression

$$
A_{nc} = \gamma Q_{em} + Z^0(I_L^3 - \sin^2\theta_W Q_{em}) \;.
\tag{A-2.36}
$$

Here the electromagnetic charge Q_{em} and the weak isospin are defined by

$$
\begin{aligned}
Q_{em} &= \Sigma^{12} + \frac{(n_+1_+ + n_-1_-)}{6} \;, \\
I_L^3 &= \frac{(\Sigma^{12} - \Sigma^{03})}{2} \;.
\end{aligned}
\tag{A-2.37}
$$

The fields γ and Z^0 are defined via the relations

$$
\begin{aligned}
\gamma &= 6d\bar{\gamma} = \frac{6}{(a+b)}(aX + bY) \;, \\
Z^0 &= 4(a+b)\bar{Z}^0 = 4(X - Y) \;.
\end{aligned}
\tag{A-2.38}
$$

The value of the Weinberg angle is given by

$$sin^2\theta_W \quad = \quad \frac{3b}{2(a+b)} \quad , \tag{A-2.39}$$

and is not fixed completely. Observe that right handed neutrinos decouple completely from the electro-weak interactions.

The determination of the value of the Weinberg angle is a dynamical problem. The original approach was based on the assumption that it makes sense to talk about electroweak action defined at fundamental level and introduce a symmetry breaking by adding an additional term proportional to Kähler action. The recent view is that Kähler action plus volume term defines the fundamental action.

The Weinberg angle is completely fixed if one requires that the electroweak action contains no cross term of type γZ^0. This leads to a definite value for the Weinberg angle.

One can however add a symmetry breaking term proportional to Kähler action and this changes the value of the Weinberg angle. As a matter fact, color gauge action identifying color gauge field as proportional to $H^A J_{\alpha\beta}$ is proportional to Kähler action. A possible interpretation would be as a sum of electroweak and color gauge interactions.

To evaluate the value of the Weinberg angle one can express the neutral part F_{nc} of the induced gauge field as

$$F_{nc} \quad = \quad 2R_{03}\Sigma^{03} + 2R_{12}\Sigma^{12} + J(n_+1_+ + n_-1_-) \quad , \tag{A-2.40}$$

where one has

$$\begin{aligned} R_{03} &= 2(2e^0 \wedge e^3 + e^1 \wedge e^2) \quad , \\ R_{12} &= 2(e^0 \wedge e^3 + 2e^1 \wedge e^2) \quad , \\ J &= 2(e^0 \wedge e^3 + e^1 \wedge e^2) \quad , \end{aligned} \tag{A-2.41}$$

in terms of the fields γ and Z^0 (photon and Z- boson)

$$F_{nc} \quad = \quad \gamma Q_{em} + Z^0(I_L^3 - sin^2\theta_W Q_{em}) \quad . \tag{A-2.42}$$

Evaluating the expressions above, one obtains for γ and Z^0 the expressions

$$\begin{aligned} \gamma &= 3J - sin^2\theta_W R_{12} \quad , \\ Z^0 &= 2R_{03} \quad . \end{aligned} \tag{A-2.43}$$

For the Kähler field one obtains

$$J \quad = \quad \frac{1}{3}(\gamma + sin^2\theta_W Z^0) \quad . \tag{A-2.44}$$

Expressing the neutral part of the symmetry broken YM action

$$\begin{aligned} L_{ew} &= L_{sym} + fJ^{\alpha\beta}J_{\alpha\beta} \quad , \\ L_{sym} &= \frac{1}{4g^2}Tr(F^{\alpha\beta}F_{\alpha\beta}) \quad , \end{aligned} \tag{A-2.45}$$

where the trace is taken in spinor representation, in terms of γ and Z^0 one obtains for the coefficient X of the γZ^0 cross term (this coefficient must vanish) the expression

$$X = -\frac{K}{2g^2} + \frac{fp}{18} \ ,$$
$$K = Tr\left[Q_{em}(I_L^3 - sin^2\theta_W Q_{em})\right] \ , \tag{A-2.46}$$

This parameter can be calculated by substituting the values of quark and lepton charges and weak isospins.

In the general case the value of the coefficient K is given by

$$K = \sum_i \left[-\frac{(18 + 2n_i^2)sin^2\theta_W}{9}\right] \ , \tag{A-2.47}$$

where the sum is over the spinor chiralities, which appear as elementary fermions and n_i is the integer describing the coupling of the spinor field to the Kähler potential. The cross term vanishes provided the value of the Weinberg angle is given by

$$sin^2\theta_W = \frac{9\sum_i 1}{(fg^2 + 2\sum_i(18 + n_i^2))} \ . \tag{A-2.48}$$

In the scenario where both leptons and quarks are elementary fermions the value of the Weinberg angle is given by

$$sin^2\theta_W = \frac{9}{(\frac{fg^2}{2} + 28)} \ . \tag{A-2.49}$$

The bare value of the Weinberg angle is $9/28$ in this scenario, which is not far from the typical value $9/24$ of GUTs at high energies [B7]. The experimental value at the scale length scale of the electron can be deduced from the ratio of W and Z boson masses as $sin^2\theta_W = 1 - (m_W/m_Z)^2 \simeq .22290$. This ratio and also the weak boson masses depend on the length scale.

If one interprets the additional term proportional to J as color action, one could perhaps interpret the value of Weinberg angle as expressing a connection between strong and weak coupling constant evolution. The limit $f \to 0$ should correspond to an infinite value of color coupling strength and at this limit one would have $sin^2\theta_W = \frac{9}{28}$ for $f/g^2 \to 0$. This does not make sense since the Weinberg angle is in the standard model much smaller in QCD scale Λ corresponding roughly to pion mass scale. The Weinberg angle is in principle predicted by the p-adic coupling constant evolution fixed by the number theoretical vision of TGD.

One could however have a sum of electroweak action, correction terms changing the value of Weinberg angle, and color action and coupling constant evolution could be understood in terms of the coupling parameters involved.

Electroweak symmetry breaking

One of the hardest challenges in the development of the TGD based view of weak symmetry breaking was the fact that classical field equations allow space-time surfaces with finite but arbitrarily large size. For a fixed space-time surface, the induced gauge fields, including classical weak fields, are long ranged. On the other hand, the large mass for weak bosons would require a short correlation length. How can one understand this together with the fact that a photon has a long correlation length?

In zero energy ontology quantum states are superpositions of space-time surfaces as analogs of almost unique Bohr orbits of particles identified as 3-D surfaces. For some reason the superposition should be such that the quantum averages of weak gauge boson fields vanish below the weak scale whereas the quantum average of electromagnetic fields is non-vanishing.

This is indeed the case.

1. The supersymplectic symmetries form isometries of the world of classical worlds (WCW) and they act in CP_2 degrees of freedom as symplectic transformations leaving the CP_2 symplectic form J invariant and therefore also its contribution to the electromagnetic field since this part is the same for all space-time surfaces in the superposition of space-time surfaces as a representation of supersymplectic isometry group (as a special case a representation of color group).

2. In TGD, color and electroweak symmetries acting as holonomies are not independent and for the $SU(2)_L$ part of induced spinor connection the symplectic transformations induces $SU(2)_L \times U(1)_R$ gauge transformation. This suggests that the quantum expectations of the induced weak fields over the space-time surfaces vanish above the quantum coherence scale. The averages of W and of the left handed part of Z^0 should therefore vanish.

3. $\langle Z^0 \rangle$ should vanish. For $U(1)_R$ part of Z^0, the action of gauge transformation is trivial in gauge theory. Now however the space-time surface changes under symplectic transformations and this could make the average of the right-handed part of Z^0 vanishing. The vanishing of the average of the axial part of the Z^0 is suggested by the partially conserved axial current hypothesis.

One can formulate this picture quantitatively.

1. The electromagnetic field [L135] contains, besides the induced Kähler form, also the induced curvature form R_{12}, which couples vectorially. Conserved vector current hypothesis suggests that the average of R_{12} is non-vanishing. One can express the neutral part of the induced gauge field in terms of induced spinor curvature and Kähler form J as

$$
\begin{aligned}
R_{03} &= 2(2e^0 \wedge e^3 + e^1 \wedge e^2) = J + 2e^0 \wedge e^3 \ , \\
J &= 2(e^0 \wedge e^3 + e^1 \wedge e^2) \ , \\
R_{12} &= 2(e^0 \wedge e^3 + 2e^1 \wedge e^2) = 3J - 2e^0 \wedge e^3 \quad ,
\end{aligned}
\tag{A-2.50}
$$

2. The induced fields γ and Z^0 (photon and Z- boson) can be expressed as

$$
\begin{aligned}
\gamma &= 3J - sin^2\theta_W R_{12} \ , \\
Z^0 &= 2R_{03} = 2(J + 2e^0 \wedge e^3)
\end{aligned}
\tag{A-2.51}
$$
$$
per.
\tag{A-2.52}
$$

The condition $\langle Z^0 \rangle = 0$ gives $2\langle e^0 \wedge e^3 \rangle = -2J$ and this in turn gives $\langle R_{12} \rangle = 4J$. The average over γ would be

$$
\langle \gamma \rangle = (3 - 4sin^2\theta_W)J \ .
$$

For $sin^2\theta_W = 3/4$ $langle\gamma\rangle$ would vanish.

The quantum averages of classical weak fields quite generally vanish. What about correlation functions?

1. One expects that the correlators of classical weak fields as color invariants, and perhaps even symplectic invariants, are non-vanishing below the Compton length since in this kind of situation the points in the correlation function belong to the same 3-surface representing particle, such as hadron.

2. The intuitive picture is that in longer length scales one has disjoint 3-surfaces with a size scale of Compton length. If the states associated with two disjoint 3-surfaces are separately color invariant there are no correlations in color degrees of freedom and correlators reduce to the products of expectations of classical weak fields and vanish. This could also hold when the 3-surfaces are connected by flux tube bonds.

   Below the Compton length weak bosons would thus behave as correlated massless fields. The Compton lengths of weak bosons are proportional to the value of effective Planck constant h_{eff} and in living systems the Compton lengths are proposed to be even of the order of cell size. This would explain the mysterious chiral selection in living systems requiring large parity violation.

3. What about the averages and correlators of color gauge fields? Classical color gauge fields are proportional to the products of Hamiltonians of color isometries induced Kähler form and the expectations of color Hamiltonians give vanishing average above Compton length and therefore vanishing average. Correlators are non-vanishing below the hadron scale. Gluons do not propagate in long scales for the same reason as weak bosons. This is implied by color confinement, which has also classical description in the sense that 3-surfaces have necessarily a finite size.

   A large value of h_{eff} allows colored states even in biological scales below the Compton length since in this kind of situation the points in the correlation function belong to the same 3-surface representing particle, such as dark hadron.

Discrete symmetries

The treatment of discrete symmetries C, P, and T is based on the following requirements:

1. Symmetries must be realized as purely geometric transformations.

2. Transformation properties of the field variables should be essentially the same as in the conventional quantum field theories [B9] .

   The action of the reflection P on spinors of is given by

$$\Psi \quad \rightarrow \quad P\Psi = \gamma^0 \otimes \gamma^0 \Psi \ . \tag{A-2.53}$$

in the representation of the gamma matrices for which γ^0 is diagonal. It should be noticed that W and Z^0 bosons break parity symmetry as they should since their charge matrices do not commute with the matrix of P.

The guess that a complex conjugation in CP_2 is associated with T transformation of the physicist turns out to be correct. One can verify by a direct calculation that pure Dirac action is invariant under T realized according to

$$\begin{aligned} m^k &\rightarrow T(M^k) \ , \\ \xi^k &\rightarrow \bar{\xi}^k \ , \\ \Psi &\rightarrow \gamma^1 \gamma^3 \otimes 1 \Psi \ . \end{aligned} \tag{A-2.54}$$

The operation bearing closest resemblance to the ordinary charge conjugation corresponds geometrically to complex conjugation in CP_2:

$$\begin{aligned} \xi^k &\rightarrow \bar{\xi}^k \ , \\ \Psi &\rightarrow \Psi^\dagger \gamma^2 \gamma^0 \otimes 1 \ . \end{aligned} \tag{A-2.55}$$

As one might have expected symmetries CP and T are exact symmetries of the pure Dirac action.

A-3 Induction procedure and many-sheeted space-time

Since the classical gauge fields are closely related in TGD framework, it is not possible to have space-time sheets carrying only single kind of gauge field. For instance, em fields are accompanied by Z^0 fields for extremals of Kähler action.

Classical em fields are always accompanied by Z^0 field and some components of color gauge field. For extremals having homologically non-trivial sphere as a CP_2 projection em and Z^0 fields are the only non-vanishing electroweak gauge fields. For homologically trivial sphere only W fields are non-vanishing. Color rotations does not affect the situation.

For vacuum extremals all electro-weak gauge fields are in general non-vanishing although the net gauge field has U(1) holonomy by 2-dimensionality of the CP_2 projection. Color gauge field has $U(1)$ holonomy for all space-time surfaces and quantum classical correspondence suggest a weak form of color confinement meaning that physical states correspond to color neutral members of color multiplets.

A-3.1 Induction procedure for gauge fields and spinor connection

Induction procedure for gauge potentials and spinor structure is a standard procedure of bundle theory. If one has embedding of some manifold to the base space of a bundle, the bundle structure can be induced so that it has as a base space the imbedded manifold, whose points have as fiber the fiber if embedding space at their image points. In the recent case the embedding of space-time surface to embedding space defines the induction procedure. The induced gauge potentials and gauge fields are projections of the spinor connection of the embedding space to the space-time surface (see http://tgdtheory.fi/appfigures/induct.jpg).

Induction procedure makes sense also for the spinor fields of embedding space and one obtains geometrization of both electroweak gauge potentials and of spinors. The new element is induction of gamma matrices which gives their projections at space-time surface.

As a matter fact, the induced gamma matrices cannot appear in the counterpart of massless Dirac equation. To achieve super-symmetry, Dirac action must be replaced with Kähler-Dirac action for which gamma matrices are contractions of the canonical momentum currents of Kähler action with embedding space gamma matrices. Induced gamma matrices in Dirac action would correspond to 4-volume as action.

Fig. 9. Induction of spinor connection and metric as projection to the space-time surface. http://tgdtheory.fi/appfigures/induct.jpg.

A-3.2 Induced gauge fields for space-times for which CP_2 projection is a geodesic sphere

If one requires that space-time surface is an extremal of Kähler action and has a 2-dimensional CP_2 projection, only vacuum extremals and space-time surfaces for which CP_2 projection is a geodesic sphere, are allowed. Homologically non-trivial geodesic sphere correspond to vanishing W fields and homologically non-trivial sphere to non-vanishing W fields but vanishing γ and Z^0. This can be verified by explicit examples.

$r = \infty$ surface gives rise to a homologically non-trivial geodesic sphere for which e_0 and e_3 vanish imply the vanishing of W field. For space-time sheets for which CP_2 projection is $r = \infty$ homologically non-trivial geodesic sphere of CP_2 one has

$$\gamma = (\frac{3}{4} - \frac{sin^2(\theta_W)}{2})Z^0 \simeq \frac{5Z^0}{8} \quad .$$

The induced W fields vanish in this case and they vanish also for all geodesic sphere obtained by $SU(3)$ rotation.

$Im(\xi^1) = Im(\xi^2) = 0$ corresponds to homologically trivial geodesic sphere. A more general representative is obtained by using for the phase angles of standard complex CP_2 coordinates constant values. In this case e^1 and e^3 vanish so that the induced em, Z^0, and Kähler fields vanish but induced W fields are non-vanishing. This holds also for surfaces obtained by color rotation. Hence one can say that for non-vacuum extremals with 2-D CP_2 projection color rotations and weak symmetries commute.

A-3.3 Many-sheeted space-time

TGD space-time is many-sheeted: in other words, there are in general several space-sheets which have projection to the same M^4 region. Second manner to say this is that CP_2 coordinates are many-valued functions of M^4 coordinates. The original physical interpretation of many-sheeted space-time time was not correct: it was assumed that single sheet corresponds to GRT space-time and this obviously leads to difficulties since the induced gauge fields are expressible in terms of only four embedding space coordinates.

Fig. 10. Illustration of many-sheeted space-time of TGD. `http://tgdtheory.fi/appfigures/manysheeted.jpg`

Superposition of effects instead of superposition of fields

The first objection against TGD is that superposition is not possible for induced gauge fields and induced metric. The resolution of the problem is that it is effects which need to superpose, not the fields.

Test particle topologically condenses simultaneously to all space-time sheets having a projection to same region of M^4 (that is touches them). The superposition of effects of fields at various space-time sheets replaces the superposition of fields. This is crucial for the understanding also how GRT space-time relates to TGD space-time, which is also in the appendix of this book).

Wormhole contacts

Wormhole contacts are key element of many-sheeted space-time. One does not expect them to be stable unless there is non-trivial Kähler magnetic flux flowing through then so that the throats look like Kähler magnetic monopoles.

Fig. 11. Wormhole contact. `http://tgdtheory.fi/appfigures/wormholecontact.jpg`

Since the flow lines of Kähler magnetic field must be closed this requires the presence of another wormhole contact so that one obtains closed monopole flux tube decomposing to two Minkowskian pieces at the two space-time sheets involved and two wormhole contacts with Euclidian signature of the induced metric. These objects are identified as space-time correlates of elementary particles and are clearly analogous to string like objects.

The relationship between the many-sheeted space-time of TGD and of GRT space-time

The space-time of general relativity is single-sheeted and there is no need to regard it as surface in H although the assumption about representability as vacuum extremal gives very powerful constraints in cosmology and astrophysics and might make sense in simple situations.

The space-time of GRT can be regarded as a long length scale approximation obtained by lumping together the sheets of the many-sheeted space-time to a region of M^4 and providing it with an effective metric obtained as sum of M^4 metric and deviations of the induced metrics of various space-time sheets from M^4 metric. Also induced gauge potentials sum up in the similar manner so that also the gauge fields of gauge theories would not be fundamental fields.

Fig. 12. The superposition of fields is replaced with the superposition of their effects in many-sheeted space-time. `http://tgdtheory.fi/appfigures/fieldsuperpose.jpg`

Space-time surfaces of TGD are considerably simpler objects that the space-times of general relativity and relate to GRT space-time like elementary particles to systems of condensed matter physics. Same can be said about fields since all fields are expressible in terms of embedding space coordinates and their gradients, and general coordinate invariance means that the number of bosonic field degrees is reduced locally to 4. TGD space-time can be said to be a microscopic description whereas GRT space-time a macroscopic description. In TGD complexity of space-time topology replaces the complexity due to large number of fields in quantum field theory.

Topological field quantization and the notion of magnetic body

Topological field quantization also TGD from Maxwell's theory. TGD predicts topological light rays ("massless extremals (MEs)") as space-time sheets carrying waves or arbitrary shape propagating

with maximal signal velocity in single direction only and analogous to laser beams and carrying light-like gauge currents in the generi case. There are also magnetic flux quanta and electric flux quanta. The deformations of cosmic strings with 2-D string orbit as M^4 projection gives rise to magnetic flux tubes carrying monopole flux made possible by CP_2 topology allowing homological Kähler magnetic monopoles.

Fig. 13. Topological quantization for magnetic fields replaces magnetic fields with bundles of them defining flux tubes as topological field quanta. `http://tgdtheory.fi/appfigures/field.jpg`

The imbeddability condition for say magnetic field means that the region containing constant magnetic field splits into flux quanta, say tubes and sheets carrying constant magnetic field. Unless one assumes a separate boundary term in Kähler action, boundaries in the usual sense are forbidden except as ends of space-time surfaces at the boundaries of causal diamonds. One obtains typically pairs of sheets glued together along their boundaries giving rise to flux tubes with closed cross section possibly carrying monopole flux.

These kind of flux tubes might make possible magnetic fields in cosmic scales already during primordial period of cosmology since no currents are needed to generate these magnetic fields: cosmic string would be indeed this kind of objects and would dominated during the primordial period. Even superconductors and maybe even ferromagnets could involve this kind of monopole flux tubes.

A-3.4 Embedding space spinors and induced spinors

One can geometrize also fermionic degrees of freedom by inducing the spinor structure of $M^4 \times CP_2$.

CP_2 does not allow spinor structure in the ordinary sense but one can couple the opposite H-chiralities of H-spinors to an $n = 1$ ($n = 3$) integer multiple of Kähler gauge potential to obtain a respectable modified spinor structure. The em charges of resulting spinors are fractional (integer valued) and the interpretation as quarks (leptons) makes sense since the couplings to the induced spinor connection having interpretation in terms electro-weak gauge potential are identical to those assumed in standard model.

The notion of quark color differs from that of standard model.

1. Spinors do not couple to color gauge potential although the identification of color gauge potential as projection of $SU(3)$ Killing vector fields is possible. This coupling must emerge only at the effective gauge theory limit of TGD.

2. Spinor harmonics of embedding space correspond to triality $t = 1$ ($t = 0$) partial waves. The detailed correspondence between color and electroweak quantum numbers is however not correct as such and the interpretation of spinor harmonics of embedding space is as representations for ground states of super-conformal representations. The wormhole pairs associated with physical quarks and leptons must carry also neutrino pair to neutralize weak quantum numbers above the length scale of flux tube (weak scale or Compton length). The total color quantum numbers or these states must be those of standard model. For instance, the color quantum numbers of fundamental left-hand neutrino and lepton can compensate each other for the physical lepton. For fundamental quark-lepton pair they could sum up to those of physical quark.

   The well-definedness of em charge is crucial condition.

1. Although the embedding space spinor connection carries W gauge potentials one can say that the embedding space spinor modes have well-defined em charge. One expects that this is true for induced spinor fields inside wormhole contacts with 4-D CP_2 projection and Euclidian signature of the induced metric.

2. The situation is not the same for the modes of induced spinor fields inside Minkowskian region and one must require that the CP_2 projection of the regions carrying induced spinor field is such that the induced W fields and above weak scale also the induced Z^0 fields vanish in order to avoid large parity breaking effects. This condition forces the CP_2 projection to be 2-dimensional. For a generic Minkowskian space-time region this is achieved only if the

    spinor modes are localized at 2-D surfaces of space-time surface - string world sheets and possibly also partonic 2-surfaces.

3. Also the Kähler-Dirac gamma matrices appearing in the modified Dirac equation must vanish in the directions normal to the 2-D surface in order that Kähler-Dirac equation can be satisfied. This does not seem plausible for space-time regions with 4-D CP_2 projection.

4. One can thus say that strings emerge from TGD in Minkowskian space-time regions. In particular, elementary particles are accompanied by a pair of fermionic strings at the opposite space-time sheets and connecting wormhole contacts. Quite generally, fundamental fermions would propagate at the boundaries of string world sheets as massless particles and wormhole contacts would define the stringy vertices of generalized Feynman diagrams. One obtains geometrized diagrammatics, which brings looks like a combination of stringy and Feynman diagrammatics.

5. This is what happens in the the generic situation. Cosmic strings could serve as examples about surfaces with 2-D CP_2 projection and carrying only em fields and allowing delocalization of spinor modes to the entire space-time surfaces.

A-3.5   About induced gauge fields

In the following the induced gauge fields are studied for general space-time surface without assuming the preferred extremal property (Bohr orbit property). Therefore the following arguments are somewhat obsolete in their generality.

Space-times with vanishing em, Z^0, or Kähler fields

The following considerations apply to a more general situation in which the homologically trivial geodesic sphere and extremal property are not assumed. It must be emphasized that this case is possible in TGD framework only for a vanishing Kähler field.

    Using spherical coordinates (r, Θ, Ψ, Φ) for CP_2, the expression of Kähler form reads as

$$
\begin{aligned}
J &= \frac{r}{F^2} dr \wedge (d\Psi + cos(\Theta)d\Phi) + \frac{r^2}{2F} sin(\Theta)d\Theta \wedge d\Phi \ , \\
F &= 1 + r^2 \ .
\end{aligned}
\tag{A-3.1}
$$

The general expression of electromagnetic field reads as

$$
\begin{aligned}
F_{em} &= (3 + 2p)\frac{r}{F^2} dr \wedge (d\Psi + cos(\Theta)d\Phi) + (3 + p)\frac{r^2}{2F} sin(\Theta)d\Theta \wedge d\Phi \ , \\
p &= sin^2(\Theta_W) \ ,
\end{aligned}
\tag{A-3.2}
$$

where Θ_W denotes Weinberg angle.

1. The vanishing of the electromagnetic fields is guaranteed, when the conditions

$$
\Psi = k\Phi \ ,
$$
$$
(3 + 2p)\frac{1}{r^2 F}(d(r^2)/d\Theta)(k + cos(\Theta)) \quad + \quad (3 + p)sin(\Theta) = 0 \ ,
\tag{A-3.3}
$$

hold true. The conditions imply that CP_2 projection of the electromagnetically neutral space-time is 2-dimensional. Solving the differential equation one obtains

$$r = \sqrt{\frac{X}{1-X}} \;,$$

$$X = D\left[|\frac{k+u}{C}|\right]^{\epsilon} \;,$$

$$u \equiv cos(\Theta) \;,\;\; C = k + cos(\Theta_0) \;,\;\; D = \frac{r_0^2}{1+r_0^2} \;,\;\; \epsilon = \frac{3+p}{3+2p} \;, \tag{A-3.4}$$

where C and D are integration constants. $0 \leq X \leq 1$ is required by the reality of r. $r = 0$ would correspond to $X = 0$ giving $u = -k$ achieved only for $|k| \leq 1$ and $r = \infty$ to $X = 1$ giving $|u + k| = [(1+r_0^2)/r_0^2]^{(3+2p)/(3+p)}$ achieved only for

$$sign(u+k) \times [\frac{1+r_0^2}{r_0^2}]^{\frac{3+2p}{3+p}} \leq k+1 \;,$$

where $sign(x)$ denotes the sign of x.

The expressions for Kähler form and Z^0 field are given by

$$J = -\frac{p}{3+2p} X du \wedge d\Phi \;,$$

$$Z^0 = -\frac{6}{p} J \;. \tag{A-3.5}$$

The components of the electromagnetic field generated by varying vacuum parameters are proportional to the components of the Kähler field: in particular, the magnetic field is parallel to the Kähler magnetic field. The generation of a long range Z^0 vacuum field is a purely TGD based feature not encountered in the standard gauge theories.

2. The vanishing of Z^0 fields is achieved by the replacement of the parameter ϵ with $\epsilon = 1/2$ as becomes clear by considering the condition stating that Z^0 field vanishes identically. Also the relationship $F_{em} = 3J = -\frac{3}{4}\frac{r^2}{F} du \wedge d\Phi$ is useful.

3. The vanishing Kähler field corresponds to $\epsilon = 1, p = 0$ in the formula for em neutral space-times. In this case classical em and Z^0 fields are proportional to each other:

$$Z^0 = 2e^0 \wedge e^3 = \frac{r}{F^2}(k+u)\frac{\partial r}{\partial u} du \wedge d\Phi = (k+u) du \wedge d\Phi \;,$$

$$r = \sqrt{\frac{X}{1-X}} \;,\;\; X = D|k+u| \;,$$

$$\gamma = -\frac{p}{2} Z^0 \;. \tag{A-3.6}$$

For a vanishing value of Weinberg angle ($p = 0$) em field vanishes and only Z^0 field remains as a long range gauge field. Vacuum extremals for which long range Z^0 field vanishes but em field is non-vanishing are not possible.

The effective form of CP_2 metric for surfaces with 2-dimensional CP_2 projection

The effective form of the CP_2 metric for a space-time having vanishing em,Z^0, or Kähler field is of practical value in the case of vacuum extremals and is given by

$$
\begin{aligned}
ds^2_{eff} &= (s_{rr}(\frac{dr}{d\Theta})^2 + s_{\Theta\Theta})d\Theta^2 + (s_{\Phi\Phi} + 2ks_{\Phi\Psi})d\Phi^2 = \frac{R^2}{4}[s^{eff}_{\Theta\Theta}d\Theta^2 + s^{eff}_{\Phi\Phi}d\Phi^2] \ , \\
s^{eff}_{\Theta\Theta} &= X \times \left[\frac{\epsilon^2(1-u^2)}{(k+u)^2} \times \frac{1}{1-X} + 1 - X\right] \ , \\
s^{eff}_{\Phi\Phi} &= X \times \left[(1-X)(k+u)^2 + 1 - u^2\right] \ ,
\end{aligned}
\tag{A-3.7}
$$

and is useful in the construction of vacuum embedding of, say Schwartchild metric.

Topological quantum numbers

Space-times for which either em, Z^0, or Kähler field vanishes decompose into regions characterized by six vacuum parameters: two of these quantum numbers (ω_1 and ω_2) are frequency type parameters, two (k_1 and k_2) are wave vector like quantum numbers, two of the quantum numbers (n_1 and n_2) are integers. The parameters ω_i and n_i will be referred as electric and magnetic quantum numbers. The existence of these quantum numbers is not a feature of these solutions alone but represents a much more general phenomenon differentiating in a clear cut manner between TGD and Maxwell's electrodynamics.

The simplest manner to avoid surface Kähler charges and discontinuities or infinities in the derivatives of CP_2 coordinates on the common boundary of two neighboring regions with different vacuum quantum numbers is topological field quantization, 3-space decomposes into disjoint topological field quanta, 3-surfaces having outer boundaries with possibly macroscopic size.

Under rather general conditions the coordinates Ψ and Φ can be written in the form

$$
\begin{aligned}
\Psi &= \omega_2 m^0 + k_2 m^3 + n_2\phi + \text{Fourier expansion} \ , \\
\Phi &= \omega_1 m^0 + k_1 m^3 + n_1\phi + \text{Fourier expansion} \ .
\end{aligned}
\tag{A-3.8}
$$

m^0,m^3 and ϕ denote the coordinate variables of the cylindrical M^4 coordinates) so that one has $k = \omega_2/\omega_1 = n_2/n_1 = k_2/k_1$. The regions of the space-time surface with given values of the vacuum parameters ω_i,k_i and n_i and m and C are bounded by the surfaces at which space-time surface becomes ill-defined, say by $r > 0$ or $r < \infty$ surfaces.

The space-time surface decomposes into regions characterized by different values of the vacuum parameters r_0 and Θ_0. At $r = \infty$ surfaces n_2,ω_2 and m can change since all values of Ψ correspond to the same point of CP_2: at $r = 0$ surfaces also n_1 and ω_1 can change since all values of Φ correspond to same point of CP_2, too. If $r = 0$ or $r = \infty$ is not in the allowed range space-time surface develops a boundary.

This implies what might be called topological quantization since in general it is not possible to find a smooth global embedding for, say a constant magnetic field. Although global embedding exists it decomposes into regions with different values of the vacuum parameters and the coordinate u in general possesses discontinuous derivative at $r = 0$ and $r = \infty$ surfaces. A possible manner to avoid edges of space-time is to allow field quantization so that 3-space (and field) decomposes into disjoint quanta, which can be regarded as structurally stable units a 3-space (and of the gauge field). This doesn't exclude partial join along boundaries for neighboring field quanta provided some additional conditions guaranteeing the absence of edges are satisfied.

For instance, the vanishing of the electromagnetic fields implies that the condition

$$
\Omega \equiv \frac{\omega_2}{n_2} - \frac{\omega_1}{n_1} = 0 \ ,
\tag{A-3.9}
$$

is satisfied. In particular, the ratio ω_2/ω_1 is rational number for the electromagnetically neutral regions of space-time surface. The change of the parameter n_1 and n_2 (ω_1 and ω_2) in general generates magnetic field and therefore these integers will be referred to as magnetic (electric) quantum numbers.

A-4 The relationship of TGD to QFT and string models

The recent view of the relationship of TGD to QFT and string models has developed slowly during years and it seems that in a certain sense TGD means a return to roots: instead of QFT like description involving path integral one would have wave mechanics for 3-surfaces.

A-4.1 TGD as a generalization of wave mechanism obtained by replacing point-like particles with 3-surfaces

The first vision of TGD was as a generalization of quantum field theory (string models) obtained by replacing pointlike particles (strings) as fundamental objects with 3-surfaces.

The later work has revealed that TGD could be seen as a generalization of the wave mechanism based on the replacement of a point-like particle with 3-D surface. This is due to holography implied by general coordinate invariance. The definition of the metric of the "world of classical worlds" (WCW) must assign a unique or at least almost unique space-time surface to a given 3-surface. This 4-surface is analogous to Bohr orbit so that also Bohr orbitology becomes an exact part of quantum physics. The failure of strict determinism forces to replace 3-surfaces with 4-surfaces and this leads to zero energy ontology (ZEO) in which quantum states are superpositions of space-time surfaces [K55, K35, K99] [L111, L124].

Fig. 5. TGD replaces point-like particles with 3-surfaces. `http://tgdtheory.fi/appfigures/particletgd.jpg`

A-4.2 Extension of superconformal invariance

The fact that light-like 3-surfaces are effectively metrically 2-dimensional and thus possess generalization of 2-dimensional conformal symmetries with light-like radial coordinate defining the analog of second complex coordinate suggests that this generalization could work and extend the super-conformal symmetries to their 4-D analogs.

The boundary $\delta M_+^4 = S^2 \times R_+$- of 4-D light-cone M_+^4 is also metrically 2-dimensional and allows extended conformal invariance. Also the group of isometries of light-cone boundary and of light-like 3-surfaces is infinite-dimensional since the conformal scalings of S^2 can be compensated by S^2-local scaling of the light-like radial coordinate of R_+. These simple facts mean that 4-dimensional Minkowski space and 4-dimensional space-time surfaces are in a completely unique position as far as symmetries are considered.

In fact, this leads to a generalization of the Kac-Moody type symmetries of string models. $\delta M_+^4 \times CP_2$ allows huge supersymplectic symmetries for which the radial light-like coordinate of δM_+^4 plays the role of complex string coordinate in string models. These symmetries are assumed to act as isometries of WCW.

A-4.3 String-like objects and strings

String like objects obtained as deformations of cosmic strings $X^2 \times Y^2$, where X^2 is minimal surface in M^4 and Y^2 a holomorphic surface of CP_2 are fundamental extremals of Kähler action having string world sheet as M^4 projections. Cosmic strings dominate the primordial cosmology of the TGD Universe and the inflationary period corresponds to the transition to radiation dominated cosmology for which space-time sheets with 4-D M^4 projection dominate.

Also genuine string-like objects emerge from TGD. The conditions that the em charge of modes of induces spinor fields is well-defined requires in the generic case the localization of the modes at 2-D surfaces -string world sheets and possibly also partonic 2-surfaces. This in Minkowskian space-time regions.

Fig. 6. Well-definedness of em charge forces the localization of induced spinor modes to 2-D surfaces in generic situations in Minkowskian regions of space-time surface. `http://tgdtheory.fi/appfigures/fermistring.jpg`

A-4.4 TGD view of elementary particles

The TGD based view about elementary particles has two key aspects.

1. The space-time correlates of elementary particles are identified as pairs of wormhole contacts with Euclidean signature of metric and having 4-D CP_2 projection. Their throats behave effectively as Kähler magnetic monopoles so that wormhole throats must be connected by Kähler magnetic flux tubes with monopole flux so that closed flux tubes are obtained.

2. At the level of H Fermion number is carried by the modes of the induced spinor field. In space-time regions with Minkowski signature the modes are localized at string world sheets connecting the wormhole contacts.

Fig. 7. TGD view about elementary particles. a) Particle orbit corresponds to a 4-D generalization of a world line or b) with its light-like 3-D boundary (holography). c) Particle world lines have Euclidean signature of the induced metric. d) They can be identified as wormhole contacts. e) The throats of wormhole contacts carry effective Kähler magnetic charges so that wormhole contacts must appear as pairs in order to obtain closed flux tubes. f) Wormhole contacts are accompanied by fermionic strings connecting the throats at the same sheet: the strings do not extend inside the wormhole contacts. `http://tgdtheory.fi/appfigures/elparticletgd.jpg`
Particle interactions involve both stringy and QFT aspects.

1. The boundaries of string world sheets correspond to fundamental fermions. This gives rise to massless propagator lines in generalized Feynman diagrammatics. One can speak of "long" string connecting wormhole contacts and having a hadronic string as a physical counterpart. Long strings should be distinguished from wormhole contacts which due to their super-conformal invariance behave like "short" strings with length scale given by CP_2 size, which is 10^4 times longer than Planck scale characterizing strings in string models.

2. Wormhole contact defines basic stringy interaction vertex for fermion-fermion scattering. The propagator is essentially the inverse of the superconformal scaling generator L_0. Wormhole contacts containing fermion and antifermion at its opposite throats behave like virtual bosons so that one has BFF type vertices typically.

3. In topological sense one has 3-vertices serving as generalizations of 3-vertices of Feynman diagrams. In these vertices 4-D "lines" of generalized Feynman diagrams meet along their 3-D ends. One obtains also the analogs of stringy diagrams but stringy vertices do not have the usual interpretation in terms of particle decays but in terms of propagation of particles along two different routes.

Fig. 8. a) TGD analogs of Feynman and string diagrammatics at the level of space-time topology. b) The 4-D analogs of both string diagrams and QFT diagrams appear but the interpretation of the analogs stringy diagrams is different. `http://tgdtheory.fi/appfigures/tgdgraphs.jpg`

A-5 About the selection of the action defining the Kähler function of the "world of classical worlds" (WCW)

The proposal is that space-time surfaces correspond to preferred extremals of some action principle, being analogous to Bohr orbits, so that they are almost deterministic. The action for the preferred extremal would define the Kähler function of WCW [K55, K99].

How unique is the choice of the action defining WCW Kähler metric? The problem is that twistor lift strongly suggests the identification of the preferred extremals as 4-D surfaces having 4-D generalization of complex structure and that a large number of general coordinate invariant actions constructible in terms of the induced geometry have the same preferred extremals.

A-5.1 Could twistor lift fix the choice of the action uniquely?

The twistor lift of TGD [L52] [L111, L114, L115] generalizes the notion of induction to the level of twistor fields and leads to a proposal that the action is obtained by dimensional reduction of the action having as its preferred extremals the counterpart of twistor space of the space-time surface identified as 6-D surface in the product $T(M^4) \times T(CP_2)$ twistor spaces of $T(M^4)$ and

$T(CP_2)$ of M^4 and CP_2. Only M^4 and CP_2 allow a twistor space with Kähler structure [A17] so that TGD would be unique. Dimensional reduction is forced by the condition that the 6-surface has S^2-bundle structure characterizing twistor spaces and the base space would be the space-time surface.

1. Dimensional reduction of 6-D Kähler action implies that at the space-time level the fundamental action can be identified as the sum of Kähler action and volume term (cosmological constant). Other choices of the action do not look natural in this picture although they would have the same preferred extremals.

2. Preferred extremals are proposed to correspond to minimal surfaces with singularities such that they are also extremals of 4-D Kähler action outside the singularities. The physical analogue are soap films spanned by frames and one can localize the violation of the strict determinism and of strict holography to the frames.

3. The preferred extremal property is realized as the holomorphicity characterizing string world sheets, which generalizes to the 4-D situation. This in turn implies that the preferred extremals are the same for any general coordinate invariant action defined on the induced gauge fields and induced metric apart from possible extremals with vanishing CP_2 Kähler action.

   For instance, 4-D Kähler action and Weyl action as the sum of the tensor squares of the components of the Weyl tensor of CP_2 representing quaternionic imaginary units constructed from the Weyl tensor of CP_2 as an analog of gauge field would have the same preferred extremals and only the definition of Kähler function and therefore Kähler metric of WCW would change. One can even consider the possibility that the volume term in the 4-D action could be assigned to the tensor square of the induced metric representing a quaternionic or octonionic real unit.

   Action principle does not seem to be unique. On the other hand, the WCW Kähler form and metric should be unique since its existence requires maximal isometries.

   Unique action is not the only way to achieve this. One cannot exclude the possibility that the Kähler gauge potential of WCW in the complex coordinates of WCW differs only by a complex gradient of a holomorphic function for different actions so that they would give the same Kähler form for WCW. This gradient is induced by a symplectic transformation of WCW inducing a U(1) gauge transformation. The Kähler metric is the same if the symplectic transformation is an isometry.

   Symplectic transformations of WCW could give rise to inequivalent representations of the theory in terms of action at space-time level. Maybe the length scale dependent coupling parameters of an effective action could be interpreted in terms of a choice of WCW Kähler function, which maximally simplifies the computations at a given scale.

1. The 6-D analogues of electroweak action and color action reducing to Kähler action in 4-D case exist. The 6-D analog of Weyl action based on the tensor representation of quaternionic imaginary units does not however exist. One could however consider the possibility that only the base space of twistor space $T(M^4)$ and $T(CP_2)$ have quaternionic structure.

2. Kähler action has a huge vacuum degeneracy, which clearly distinguishes it from other actions. The presence of the volume term removes this degeneracy. However, for minimal surfaces having CP_2 projections, which are Lagrangian manifolds and therefore have a vanishing induced Kähler form, would be preferred extremals according to the proposed definition. For these 4-surfaces, the existence of the generalized complex structure is dubious.

   For the electroweak action, the terms corresponding to charged weak bosons eliminate these extremals and one could argue that electroweak action or its sum with the analogue of color action, also proportional Kähler action, defines the more plausible choice. Interestingly, also the neutral part of electroweak action is proportional to Kähler action.

   Twistor lift strongly suggests that also M^4 has the analog of Kähler structure. M^8 must be complexified by adding a commuting imaginary unit i. In the E^8 subspace, the Kähler structure of E^4 is defined in the standard sense and it is proposed that this generalizes to M^4 allowing also

generalization of the quaternionic structure. M^4 Kähler structure violates Lorentz invariance but could be realized at the level of moduli space of these structures.

The minimal possibility is that the M^4 Kähler form vanishes: one can have a different representation of the Kähler gauge potential for it obtained as generalization of symplectic transformations acting non-trivially in M^4. The recent picture about the second quantization of spinors of $M^4 \times CP_2$ assumes however non-trivial Kähler structure in M^4.

A-5.2   Two paradoxes

TGD view leads to two apparent paradoxes.

1. If the preferred extremals satisfy 4-D generalization of holomorphicity, a very large set of actions gives rise to the same preferred extremals unless there are some additional conditions restricting the number of preferred extremals for a given action.

2. WCW metric has an infinite number of zero modes, which appear as parameters of the metric but do not contribute to the line element. The induced Kähler form depends on these degrees of freedom. The existence of the Kähler metric requires maximal isometries, which suggests that the Kähler metric is uniquely fixed apart from a conformal scaling factor Ω depending on zero modes. This cannot be true: galaxy and elementary particle cannot correspond to the same Kähler metric.

Number theoretical vision and the hierarchy of inclusions of HFFs associated with supersymplectic algebra actings as isometries of WcW provide equivalent realizations of the measurement resolution. This solves these paradoxes and predicts that WCW decomposes into sectors for which Kähler metrics of WCW differ in a natural way.

The hierarchy subalgebras of supersymplectic algebra implies the decomposition of WCW into sectors with different actions

Supersymplectic algebra of $\delta M_+^4 \times CP_2$ is assumed to act as isometries of WCW [L124]. There are also other important algebras but these will not be discussed now.

1. The symplectic algebra A of $\delta M_+^4 \times CP_2$ has the structure of a conformal algebra in the sense that the radial conformal weights with non-negative real part, which is half integer, label the elements of the algebra have an interpretation as conformal weights.

   The super symplectic algebra A has an infinite hierarchy of sub-algebras [L124] such that the conformal weights of sub-algebras $A_{n(SS)}$ are integer multiples of the conformal weights of the entire algebra. The superconformal gauge conditions are weakened. Only the subalgebra $A_{n(SS)}$ and the commutator $[A_{n(SS)}, A]$ annihilate the physical states. Also the corresponding classical Noether charges vanish for allowed space-time surfaces.

   This weakening makes sense also for ordinary superconformal algebras and associated Kac-Moody algebras. This hierarchy can be interpreted as a hierarchy symmetry breakings, meaning that sub-algebra $A_{n(SS)}$ acts as genuine dynamical symmetries rather than mere gauge symmetries. It is natural to assume that the super-symplectic algebra A does not affect the coupling parameters of the action.

2. The generators of A correspond to the dynamical quantum degrees of freedom and leave the induced Kähler form invariant. They affect the induced space-time metric but this effect is gravitational and very small for Einsteinian space-time surfaces with 4-D M^4 projection.

   The number of dynamical degrees of freedom increases with $n(SS)$. Therefore WCW decomposes into sectors labelled by $n(SS)$ with different numbers of dynamical degrees of freedom so that their Kähler metrics cannot be equivalent and cannot be related by a symplectic isometry. They can correspond to different actions.

Number theoretic vision implies the decomposition of WCW into sectors with different actions

The number theoretical vision leads to the same conclusion as the hierarchy of HFFs. The number theoretic vision of TGD based on $M^8 - H$ duality [L124] predicts a hierarchy with levels labelled by the degrees $n(P)$ of rational polynomials P and corresponding extensions of rationals characterized by Galois groups and by ramified primes defining p-adic length scales.

These sequences allow us to imagine several discrete coupling constant evolutions realized at the level H in terms of action whose coupling parameters depend on the number theoretic parameters.

   1. Coupling constant evolution with respect to $n(P)$

   The first coupling constant evolution would be with respect to $n(P)$.

1. The coupling constants characterizing action could depend on the degree $n(P)$ of the polynomial defining the space-time region by $M^8 - H$ duality. The complexity of the space-time surface would increase with $n(P)$ and new degrees of freedom would emerge as the number of the rational coefficients of P.

2. This coupling constant evolution could naturally correspond to that assignable to the inclusion hierarchy of hyperfinite factors of type II_1 (HFFs). I have indeed proposed [L124] that the degree $n(P)$ equals to the number $n(braid)$ of braids assignable to HFF for which super symplectic algebra subalgebra $A_{n(SS)}$ with radial conformal weights coming as $n(SS)$-multiples of those of entire algebra A. One would have $n(P) = n(braid) = n(SS)$. The number of dynamical degrees of freedom increases with n which just as it increases with $n(P)$ and $n(SS)$.

3. The actions related to different values of $n(P) = n(braid) = n(SS)$ cannot define the same Kähler metric since the number of allowed space-time surfaces depends on $n(SS)$.

   WCW could decompose to sub-WCWs corresponding to different actions, a kind of theory space. These theories would not be equivalent. A possible interpretation would be as a hierarchy of effective field theories.

4. Hierarchies of composite polynomials define sequences of polynomials with increasing values of $n(P)$ such that the order of a polynomial at a given level is divided by those at the lower levels. The proposal is that the inclusion sequences of extensions are realized at quantum level as inclusion hierarchies of hyperfinite factors of type II_1.

   A given inclusion hierarchy corresponds to a sequence $n(SS)_i$ such that $n(SS)_i$ divides $n(SS)_{i+1}$. Therefore the degree of the composite polynomials increases very rapidly. The values of $n(SS)_i$ can be chosen to be primes and these primes correspond to the degrees of so called prime polynomials [L117] so that the decompositions correspond to prime factorizations of integers. The "densest" sequence of this kind would come in powers of 2 as $n(SS)_i = 2^i$. The corresponding p-adic length scales (assignable to maximal ramified primes for given $n(SS)_i$) are expected to increase roughly exponentially, say as 2^{r2^i}. $r = 1/2$ would give a subset of scales $2^{r/2}$ allowed by the p-adic length scale hypothesis. These transitions would be very rare.

   A theory corresponding to a given composite polynomial would contain as sub-theories the theories corresponding to lower polynomial composites. The evolution with respect to $n(SS)$ would correspond to a sequence of phase transitions in which the action genuinely changes. For instance, color confinement could be seen as an example of this phase transition.

5. A subset of p-adic primes allowed by the p-adic length scale hypothesis $p \simeq 2^k$ defining the proposed p-adic length scale hierarchy could relate to n_S changing phase transition. TGD suggests a hierarchy of hadron physics corresponding to a scale hierarchy defined by Mersenne primes and their Gaussian counterparts [K71, K72]). Each of them would be characterized by a confinement phase transition in which n_S and therefore also the action changes.

2. Coupling constant evolutions with respect to ramified primes for a given value of $n(P)$

For a given value of $n(P)$, one could have coupling constant sub-evolutions with respect to the set of ramified primes of P and dimensions $n = h_{eff}/h_0$ of algebraic extensions. The action would only change by U(1) gauge transformation induced by a symplectic isometry of WCW. Coupling parameters could change but the actions would be equivalent.

The choice of the action in an optimal manner in a given scale could be seen as a choice of the most appropriate effective field theory in which radiative corrections would be taken into account. One can interpret the possibility to use a single choice of coupling parameters in terms of quantum criticality.

The range of the p-adic length scales labelled by ramified primes and effective Planck constants h_{eff}/h_0 is finite for a given value of $n(SS)$.

The first coupling constant evolution of this kind corresponds to ramified primes defining p-adic length scales for given $n(SS)$.

1. Ramified primes are factors of the discriminant $D(P)$ of P, which is expressible as a product of non-vanishing root differents and reduces to a polynomial of the n coefficients of P. Ramified primes define p-adic length scales assignable to the particles in the amplitudes scattering amplitudes defined by zero energy states.

   P would represent the space-time surface defining an interaction region in $N-$-particle scattering. The N ramified primes dividing $D(P)$ would characterize the p-adic length scales assignable to these particles. If $D(P)$ reduces to a single ramified prime, one has elementary particle [L117], and the forward scattering amplitude corresponds to the propagator.

   This would give rise to a multi-scale p-adic length scale evolution of the amplitudes analogous to the ordinary continuous coupling constant evolution of n-point scattering amplitudes with respect to momentum scales of the particles. This kind of evolutions extend also to evolutions with respect to $n(SS)$.

2. According to [L117], physical constraints require that $n(P)$ and the maximum size of the ramified prime of P correlate.

   A given rational polynomial of degree $n(P)$ can be always transformed to a polynomial with integer coefficients. If the integer coefficients are smaller than $n(P)$, there is an upper bound for the ramified primes. This assumption also implies that finite fields become fundamental number fields in number theoretical vision [L117].

3. p-Adic length scale hypothesis [L125] in its basic form states that there exist preferred primes $p \simeq 2^k$ near some powers of 2. A more general hypothesis states that also primes near some powers of 3 possibly also other small primes are preferred physically. The challenge is to understand the origin of these preferred scales.

   For polynomials P with a given degree $n(P)$ for which discriminant $D(P)$ is prime, there exists a maximal ramified prime. Numerical calculations suggest that the upper bound depends exponentially on $n(P)$.

   Could these maximal ramified primes satisfy the p-adic length scale hypothesis or its generalization? The maximal prime defines a fixed point of coupling constant evolution in accordance with the earlier proposal. For instance, could one think that one has $p \simeq 2^k$, $k = n(SS)$? Each p-adic prime would correspond to a p-adic coupling constant sub-evolution representable in terms of symplectic isometries.

Also the dimension n of the algebraic extension associated with P, which is identified in terms of effective Planck constant $h_{eff}/h_0 = n$ labelling different phases of the ordinary matter behaving like dark matter, could give rise to coupling constant evolution for given $n(SS)$. The range of allowed values of n is finite. Note however that several polynomials of a given degree can correspond to the same dimension of extension.

Number theoretic discretization of WCW and maxima of WCW Kähler function

Number theoretic approach involves a unique discretization of space-time surface and also of WCW. The question is how the points of the discretized WCW correspond to the preferred extremals.

1. The exponents of Kähler function for the maxima of Kähler function, which correspond to the universal preferred extremals, appear in the scattering amplitudes. The number theoretical approach involves a unique discretization of space-time surfaces defining the WCW coordinates of the space-time surface regarded as a point of WCW.

   In [L124] it is assumed that these WCW points appearing in the number theoretical discretization correspond to the maxima of the Kähler function. The maxima would depend on the action and would differ for ghd maxima associated with different actions unless they are not related by symplectic WCW isometry.

2. The symplectic transformations of WCW acting as isometries are assumed to be induced by the symplectic transformations of $\delta M_+^4 \times CP_2$ [K55, K35]. As isometries they would naturally permute the maxima with each other.

A-6 Number theoretic vision of TGD

Physics as number theory vision is complementary to the physics as geometry vision and has developed gradually since 1993. Langlands program is the counterpart of this vision in mathematics [L121].
     The notion of p-adic number fields emerged with the motivation coming from the observation that elementary particle mass scales and mass ratios could be understood in terms of the so-called p-adic length scale hypothesis [K76, K64, K33]. The fusion of the various p-adic physics leads to what I call adelic physics [L50, L51]. Later the hypothesis about hierarchy of Planck constants labelling phases of ordinary matter behaving like dark matter emerged [K37, K38, K39, K40].

     Eventually this led to that the values of effective Planck constant could be identified as the dimension of an algebraic extension of rationals assignable to polynomials with rational coefficients. This led to the number theoretic vision in which so-called $M^8 - H$ duality [L96, L97] plays a key role. M^8 (actually a complexification of real M^8) is analogous to momentum space so that the duality generalizes momentum position duality for point-like particles. M^8 has an interpretation as complexified octonions.
     The dynamics of 4-surfaces in M^8 is coded by polynomials with rational coefficients, whose roots define mass shells H^3 of $M^4 \subset M^8$. It has turned out that the polynomials satisfy stringent additional conditions and one can speak of number theoretic holography [L117, L121]. Also the ordinary $3 \rightarrow 4$ holography is needed to assign 4-surfaces with these 3-D mass shells. The number theoretic dynamics is based on the condition that the normal space of the 4-surface in M^8 is associative (quaternionic) and contains a commutative complex sub-space. This makes it possible to assign to this surface space-time surface in $H = M^4 \times CP_2$.
     At the level of H the space-time surfaces are by holography preferred extremals and are assumed to be determined by the twistor lift of TGD [L52] giving rise to an action which is sum of the Kähler action and volume term. The preferred extremals would be minimal surfaces analogous to soap films spanned by frames. Outside frames they would be simultaneous extremals of the Kähler action, which requires a generalization of the holomorphy characterizing string world sheets.
     In the following only p-adic numbers and hierarchy of Planck constants will be discussed.

A-6.1 p-Adic numbers and TGD

p-Adic number fields

p-Adic numbers (p is prime: 2, 3, 5, ...) can be regarded as a completion of the rational numbers using a norm, which is different from the ordinary norm of real numbers [A10]. p-Adic numbers are representable as power expansion of the prime number p of form

$$x = \sum_{k \geq k_0} x(k)p^k, \; x(k) = 0, ..., p-1 \; . \tag{A-6.1}$$

The norm of a p-adic number is given by

$$|x| = p^{-k_0(x)} \ . \tag{A-6.2}$$

Here $k_0(x)$ is the lowest power in the expansion of the p-adic number. The norm differs drastically from the norm of the ordinary real numbers since it depends on the lowest pinary digit of the p-adic number only. Arbitrarily high powers in the expansion are possible since the norm of the p-adic number is finite also for numbers, which are infinite with respect to the ordinary norm. A convenient representation for p-adic numbers is in the form

$$x = p^{k_0}\varepsilon(x) \ , \tag{A-6.3}$$

where $\varepsilon(x) = k + ...$ with $0 < k < p$, is p-adic number with unit norm and analogous to the phase factor $exp(i\phi)$ of a complex number.

The distance function $d(x,y) = |x - y|_p$ defined by the p-adic norm possesses a very general property called ultra-metricity:

$$d(x,z) \leq max\{d(x,y), d(y,z)\} \ . \tag{A-6.4}$$

The properties of the distance function make it possible to decompose R_p into a union of disjoint sets using the criterion that x and y belong to same class if the distance between x and y satisfies the condition

$$d(x,y) \leq D \ . \tag{A-6.5}$$

This division of the metric space into classes has following properties:

1. Distances between the members of two different classes X and Y do not depend on the choice of points x and y inside classes. One can therefore speak about distance function between classes.

2. Distances of points x and y inside single class are smaller than distances between different classes.

3. Classes form a hierarchical tree.

Notice that the concept of the ultra-metricity emerged in physics from the models for spin glasses and is believed to have also applications in biology [B18]. The emergence of p-adic topology as the topology of the effective space-time would make ultra-metricity property basic feature of physics.

Canonical correspondence between p-adic and real numbers

The basic challenge encountered by p-adic physicist is how to map the predictions of the p-adic physics to real numbers. p-Adic probabilities provide a basic example in this respect. Identification via common rationals and canonical identification and its variants have turned out to play a key role in this respect.

1. Basic form of the canonical identification

There exists a natural continuous map $I : R_p \to R_+$ from p-adic numbers to non-negative real numbers given by the "pinary" expansion of the real number for $x \in R$ and $y \in R_p$ this correspondence reads

$$y = \sum_{k>N} y_k p^k \to x = \sum_{k<N} y_k p^{-k} \ ,$$
$$y_k \in \{0, 1, .., p-1\} \ . \tag{A-6.6}$$

This map is continuous as one easily finds out. There is however a little difficulty associated with the definition of the inverse map since the pinary expansion like also decimal expansion is not unique (1 = 0.999...) for the real numbers x, which allow pinary expansion with finite number of pinary digits

$$x = \sum_{k=N_0}^{N} x_k p^{-k} \ ,$$

$$x = \sum_{k=N_0}^{N-1} x_k p^{-k} + (x_N - 1)p^{-N} + (p-1)p^{-N-1} \sum_{k=0,..} p^{-k} \ .$$

(A-6.7)

The p-adic images associated with these expansions are different

$$y_1 = \sum_{k=N_0}^{N} x_k p^{k} \ ,$$

$$y_2 = \sum_{k=N_0}^{N-1} x_k p^{k} + (x_N - 1)p^{N} + (p-1)p^{N+1} \sum_{k=0,..} p^{k}$$

$$= y_1 + (x_N - 1)p^{N} - p^{N+1} \ ,$$

(A-6.8)

so that the inverse map is either two-valued for p-adic numbers having expansion with finite pinary digits or single valued and discontinuous and non-surjective if one makes pinary expansion unique by choosing the one with finite pinary digits. The finite pinary digit expansion is a natural choice since in the numerical work one always must use a pinary cutoff on the real axis.

2. The topology induced by canonical identification

The topology induced by the canonical identification in the set of positive real numbers differs from the ordinary topology. The difference is easily understood by interpreting the p-adic norm as a norm in the set of the real numbers. The norm is constant in each interval $[p^k, p^{k+1})$ (see **Fig. A-6.1**) and is equal to the usual real norm at the points $x = p^k$: the usual linear norm is replaced with a piecewise constant norm. This means that p-adic topology is coarser than the usual real topology and the higher the value of p is, the coarser the resulting topology is above a given length scale. This hierarchical ordering of the p-adic topologies will be a central feature as far as the proposed applications of the p-adic numbers are considered.

Ordinary continuity implies p-adic continuity since the norm induced from the p-adic topology is rougher than the ordinary norm. p-Adic continuity implies ordinary continuity from right as is clear already from the properties of the p-adic norm (the graph of the norm is indeed continuous from right). This feature is one clear signature of the p-adic topology.

Fig. 14. The real norm induced by canonical identification from 2-adic norm. `http://tgdtheory.fi/appfigures/norm.png`

The linear structure of the p-adic numbers induces a corresponding structure in the set of the non-negative real numbers and p-adic linearity in general differs from the ordinary concept of linearity. For example, p-adic sum is equal to real sum only provided the summands have no common pinary digits. Furthermore, the condition $x +_p y < max\{x, y\}$ holds in general for the p-adic sum of the real numbers. p-Adic multiplication is equivalent with the ordinary multiplication only provided that either of the members of the product is power of p. Moreover one has $x \times_p y < x \times y$ in general. The p-Adic negative -1_p associated with p-adic unit 1 is given by $(-1)_p = \sum_k (p-1)p^k$ and defines p-adic negative for each real number x. An interesting possibility is that p-adic linearity might replace the ordinary linearity in some strongly nonlinear systems so these systems would look simple in the p-adic topology.

These results suggest that canonical identification is involved with some deeper mathematical structure. The following inequalities hold true:

$$
\begin{aligned}
(x+y)_R &\leq& x_R + y_R \ , \\
|x|_p |y|_R \leq (xy)_R &\leq& x_R y_R \ ,
\end{aligned}
\tag{A-6.9}
$$

where $|x|_p$ denotes p-adic norm. These inequalities can be generalized to the case of $(R_p)^n$ (a linear vector space over the p-adic numbers).

$$
\begin{aligned}
(x+y)_R &\leq& x_R + y_R \ , \\
|\lambda|_p |y|_R \leq (\lambda y)_R &\leq& \lambda_R y_R \ ,
\end{aligned}
\tag{A-6.10}
$$

where the norm of the vector $x \in T_p^n$ is defined in some manner. The case of Euclidian space suggests the definition

$$
(x_R)^2 \quad = \quad (\sum_n x_n^2)_R \ .
\tag{A-6.11}
$$

These inequalities resemble those satisfied by the vector norm. The only difference is the failure of linearity in the sense that the norm of a scaled vector is not obtained by scaling the norm of the original vector. Ordinary situation prevails only if the scaling corresponds to a power of p.

These observations suggests that the concept of a normed space or Banach space might have a generalization and physically the generalization might apply to the description of some non-linear systems. The nonlinearity would be concentrated in the nonlinear behavior of the norm under scaling.

3. Modified form of the canonical identification

The original form of the canonical identification is continuous but does not respect symmetries even approximately. This led to a search of variants which would do better in this respect. The modification of the canonical identification applying to rationals only and given by

$$
I_Q(q = p^k \times \frac{r}{s}) = p^k \times \frac{I(r)}{I(s)}
\tag{A-6.12}
$$

is uniquely defined for rationals, maps rationals to rationals, has also a symmetry under exchange of target and domain. This map reduces to a direct identification of rationals for $0 \leq r < p$ and $0 \leq s < p$. It has turned out that it is this map which most naturally appears in the applications. The map is obviously continuous locally since p-adically small modifications of r and s mean small modifications of the real counterparts.

Canonical identification is in a key role in the successful predictions of the elementary particle masses. The predictions for the light elementary particle masses are within extreme accuracy same for I and I_Q but I_Q is theoretically preferred since the real probabilities obtained from p-adic ones by I_Q sum up to one in p-adic thermodynamics.

4. Generalization of number concept and notion of embedding space

TGD forces an extension of number concept: roughly a fusion of reals and various p-adic number fields along common rationals is in question. This induces a similar fusion of real and p-adic embedding spaces. Since finite p-adic numbers correspond always to non-negative reals n-dimensional space R^n must be covered by 2^n copies of the p-adic variant R_p^n of R^n each of which projects to a copy of R_+^n (four quadrants in the case of plane). The common points of p-adic and real embedding spaces are rational points and most p-adic points are at real infinity.

Real numbers and various algebraic extensions of p-adic number fields are thus glued together along common rationals and also numbers in algebraic extension of rationals whose number belong to the algebraic extension of p-adic numbers. This gives rise to a book like structure with rationals and various algebraic extensions of rationals taking the role of the back of the book. Note that Neper number is exceptional in the sense that it is algebraic number in p-adic number field Q_p satisfying $e^p \bmod p = 1$.

Fig. 15. Various number fields combine to form a book like structure. `http://tgdtheory.fi/appfigures/book.jpg`

For a given p-adic space-time sheet most points are literally infinite as real points and the projection to the real embedding space consists of a discrete set of rational points: the interpretation in terms of the unavoidable discreteness of the physical representations of cognition is natural. Purely local p-adic physics implies real p-adic fractality and thus long range correlations for the real space-time surfaces having enough common points with this projection.

p-Adic fractality means that M^4 projections for the rational points of space-time surface X^4 are related by a direct identification whereas CP_2 coordinates of X^4 at these points are related by I, I_Q or some of its variants implying long range correlates for CP_2 coordinates. Since only a discrete set of points are related in this manner, both real and p-adic field equations can be satisfied and there are no problems with symmetries. p-Adic effective topology is expected to be a good approximation only within some length scale range which means infrared and UV cutoffs. Also multi-p-fractality is possible.

The notion of p-adic manifold

The notion of p-adic manifold is needed in order to fuse real physics and various p-adic physics to a larger structure which suggests that real and p-adic number fields should be glued together along common rationals bringing in mind adeles. The notion is problematic because p-adic topology is totally disconnected implying that p-adic balls are either disjoint or nested so that ordinary definition of manifold using p-adic chart maps fails. A cure is suggested to be based on chart maps from p-adics to reals rather than to p-adics (see the appendix of the book)

The chart maps are interpreted as cognitive maps, "thought bubbles".

Fig. 16. The basic idea between p-adic manifold. `http://tgdtheory.fi/appfigures/padmanifold.jpg`

There are some problems.

1. Canonical identification does not respect symmetries since it does not commute with second pinary cutoff so that only a discrete set of rational points is mapped to their real counterparts by chart map arithmetic operations which requires pinary cutoff below which chart map takes rationals to rationals so that commutativity with arithmetics and symmetries is achieved in finite resolution: above the cutoff canonical identification is used

2. Canonical identification is continuous but does not map smooth p-adic surfaces to smooth real surfaces requiring second pinary cutoff so that only a discrete set of rational points is mapped to their real counterparts by chart map requiring completion of the image to smooth preferred extremal of Kähler action so that chart map is not unique in accordance with finite measurement resolution

3. Canonical identification violates general coordinate invariance of chart map: (cognition-induced symmetry breaking) minimized if p-adic manifold structure is induced from that for p-adic embedding space with chart maps to real embedding space and assuming preferred coordinates made possible by isometries of embedding space: one however obtains several inequivalent p-adic manifold structures depending on the choice of coordinates: these cognitive representations are not equivalent.

A-6.2 Hierarchy of Planck constants and dark matter hierarchy

Hierarchy of Planck constants was motivated by the "impossible" quantal effects of ELF em fields on vertebrate cyclotron energies $E = hf = \hbar \times eB/m$ are above thermal energy is possible only if $\hbar$ has value much larger than its standard value. Also Nottale's finding that planetary orbits migh be understood as Bohr orbits for a gigantic gravitational Planck constant.

Hierachy of Planck constant would mean that the values of Planck constant come as integer multiples of ordinary Planck constant: $h_{eff} = n \times h$. The particles at magnetic flux tubes characterized by h_{eff} would correspond to dark matter which would be invisible in the sense that only particle with same value of h_{eff} appear in the same vertex of Feynman diagram.

Hierarchy of Planck constants would be due to the non-determism of the Kähler action predicting huge vacuum degeneracy allowing all space-time surfaces which are sub-manfolds of any $M^4 \times Y^2$, where Y^2 is Lagrangian sub-manifold of CP_2. For agiven Y^2 one obtains new manifolds Y^2 by applying symplectic transformations of CP_2.

Non-determinism would mean that the 3-surface at the ends of causal diamond (CD) can be connected by several space-time surfaces carrying same conserved Kähler charges and having same values of Kähler action. Conformal symmetries defined by Kac-Moody algebra associated with the embedding space isometries could act as gauge transformations and respect the light-likeness property of partonic orbits at which the signature of the induced metric changes from Minkowskian to Euclidian (Minkowskianb space-time region transforms to wormhole contact say). The number of conformal equivalence classes of these surfaces could be finite number n and define discrete physical degree of freedom and one would have $h_{eff} = n \times h$. This degeneracy would mean "second quantization" for the sheets of n-furcation: not only one but several sheets can be realized.

This relates also to quantum criticality postulated to be the basic characteristics of the dynamics of quantum TGD. Quantum criticalities would correspond to an infinite fractal hierarchy of broken conformal symmetries defined by sub-algebras of conformal algebra with conformal weights coming as integer multiples of n. This leads also to connections with quantum criticality and hierarchy of broken conformal symmetries, p-adicity, and negentropic entanglement which by consistency with standard quantum measurement theory would be described in terms of density matrix proportional $n \times n$ identity matrix and being due to unitary entanglement coefficients (typical for quantum computing systems).

Formally the situation could be described by regarding space-time surfaces as surfaces in singular n-fold singular coverings of embedding space. A stronger assumption would be that they are expressible as as products of n_1 -fold covering of M^4 and n_2-fold covering of CP_2 meaning analogy with multi-sheeted Riemann surfaces and that M^4 coordinates are n_1-valued functions and CP_2 coordinates n_2 -valued functions of space-time coordinates for $n = n_1 \times n_2$. These singular coverings of embedding space form a book like structure with singularities of the coverings localizable at the boundaries of causal diamonds defining the back of the book like structure.

Fig. 17. Hierarchy of Planck constants. `http://tgdtheory.fi/appfigures/planckhierarchy.jpg`

A-6.3 $M^8 - H$ duality as it is towards the end of 2021

The view of $M^8 - H$ duality (see Appendix **??**) has changed considerably towards the end 2021 [L111] after the realization that this duality is the TGD counterpart of momentum position duality of wave mechanics, which is lost in QFTs. Therefore M^8 and also space-time surface is analogous to momentum space. This forced us to give up the original simple identification of the points $M^4 \subset M^4 \times E^4 = M^8$ and of $M^4 \times CP_2$ so that it respects Uncertainty Principle (UP).

The first improved guess for the duality map was the replacement with the inversion $p^k \to m^k = \hbar_{eff} p^k / p^2$ conforming in spirit with UP but turned out to be too naive.

The improved form [L111] of the $M^8 - H$ duality map takes mass shells $p^2 = m^2$ of $M^4 \subset M^8$ to cds with size $L(m) = \hbar_{eff}/m$ with a common center. The slicing by mass shells is mapped to a Russian doll like slicing by cds. Therefore would be no CDs in M^8 contrary to what I believed first.

Quantum classical correspondence (QCC) inspires the proposal that the point $p^k \in M^8$ is mapped to a geodesic line corresponding to momentum p^k starting from the common center of cds. Its intersection with the opposite boundary of cd with size $L(m)$ defines the image point. This is not yet quite enough to satisfy UP but the additional details [L111] are not needed in the sequel.

The 6-D brane-like special solutions in M^8 are of special interest in the TGD inspired theory of consciousness. They have an M^4 projection which is $E = E_n$ 3-ball. Here E_n is a root of the real polynomial P defining $X^4 \subset M_c^8$ (M^8 is complexified to M_c^8) as a "root" of its octonionic continuation [L96, L97]. E_n has an interpretation as energy, which can be complex. The original interpretation was as moment of time. For this interpretation, $M^8 - H$ duality would be a linear identification and these hyper planes would be mapped to hyperplanes in $M^4 \subset H$.

This motivated the term "very special moment in the life of self" for the image of the $E = E_n$ section of $X^4 \subset M^8$ [L83]. This notion does not make sense at the level M^8 anymore.

The modified $M^8 - H$ duality forces us to modify the original interpretation [L111]. The point $(E_n, p = 0)$ is mapped $(t_n = \hbar_{eff}/E_n, 0)$. The momenta (E_n, p) in $E = E_n$ plane are mapped to the boundary of cd and correspond to a continuous time interval at the boundary of CD: "very special moment" becomes a "very special time interval".

The quantum state however corresponds to a set of points corresponding to quark momenta, which belong to a cognitive representation and are therefore algebraic integers in the extension determined by the polynomial. These active points in E_n are mapped to a discrete set at the boundary of cd(m). A "very special moment" is replaced with a sequence of "very special moments".

So called Galois confinement [L106] forces the total momenta for bound states of quarks and antiquarks to be rational integers invariant under Galois group of extension of rationals determined by the polynomial P [L111]. These states correspond to states at boundaries of sub-CDs so that one obtains a hierarchy. Galois confinement provides a universal number theoretic mechanism for the formation of bound states.

A-7 Zero energy ontology (ZEO)

ZEO is implied by the holography forced in the TGD framework by general coordinate invariance.

A-7.1 Basic motivations and ideas of ZEO

The following gives a brief summary of ZEO [L92] [K126].

1. In ZEO quantum states are not 3-dimensional but superpositions of 4-dimensional deterministic time evolutions connecting ordinary initial 3-dimensional states. By holography they are equivalent to pairs of ordinary 3-D states identified as initial and final states of time evolution. One can say that in the TGD framework general coordinate invariance implies holography and the slight failure of its determinism in turn forces ZEO.

   Quantum jumps replace this state with a new one: a superposition of deterministic time evolutions is replaced with a new superposition. Classical determinism of individual time evolution is not violated and this solves the basic paradox of quantum measurement theory. There are two kinds of quantum jumps: ordinary ("big") state function reductions (BSFRs) changing the arrow of time and "small" state function reductions (SSFRs) (weak measurements) preserving it and giving rise to the analog of Zeno effect [L92].

2. To avoid getting totally confused it is good to emphasize some aspects of ZEO.

   (a) ZEO does not mean that physical states in the usual 3-D sense as snapshots of time evolution would have zero energy state pairs defining zero energy states as initial and final states have same conserved quantities such as energy. Conservation implies that one can adopt the conventions that the values of conserved quantities are opposite for these states so that their sum vanishes: one can think that incoming and outgoing particles come from geometric past and future is the picture used in quantum field theories.

   (b) ZEO means two times: subjective time as sequence of quantum jumps and geometric time as space-time coordinate. These times are identifiable but are strongly correlated.

3. In BSFRs the arrow of time is changed and the time evolution in the final state occurs backwards with respect to the time of the external observer. BSFRs can occur in all scales since TGD predicts a hierarchy of effective Planck constants with arbitrarily large values. There is empirical support for BSFRs.

   (a) The findings of Minev et al [L77] in atomic scale can be explained by the same mechanism [L77]. In BSFR a final zero energy state as a superposition of classical deterministic time evolutions emerges and for an observer with a standard arrow of time looks

like a superposition of deterministic smooth time evolutions leading to the final state. Interestingly, once this evolution has started, it cannot be stopped unless one changes the stimulus signal inducing the evolution in which case the process does not lead to anywhere: the interpretation would be that BSFR back to the initial state occurs!

(b) Libets' experiments about active aspects of consciousness [J22] can be understood. Subject person raises his finger and neural activity starts before the conscious decision to do so. In the physicalistic framework it is thought to lead to raising of the finger. The problem with the explanation is that the activity beginning .5 seconds earlier seems to be dissipation with a reversed arrow of time: from chaotic and disordered to ordered at around .15 seconds. ZEO explanation is that macroscopic quantum jump occurred and generated a signal proceeding backwards in time and generated neural activity and dissipated to randomness.

(c) Earthquakes involve a strange anomaly: they are preceded by ELF radiation. One would expect that they generate ELF radiation. The identification as BSFR would explain the anomaly [L81]. In biology the reversal of the arrow of time would occur routinely and be a central element of biological self-organization, in particular self-organized quantum criticality (see [L87, L142].

A-7.2 Some implications of ZEO

ZEO has profound implications for understanding self-organization and self-organized quantum criticality in terms of dissipation with non-standard arrow of time looking like generation of structures [L87, L142]. ZEO could also allow understanding of what planned actions - like realizing the experiment under consideration - could be.

1. Second law in the standard sense does not favor - perhaps even not allow - realization of planned actions. ZEO forces a generalization of thermodynamics: dissipation with a non-standard arrow of time for a subsystem would look like self-organization and planned action and its realization.

   Could most if not all planned action be like this - induced by BSFR in the geometric future and only apparently planned? There would be however the experience of planning and realizing induced by the signals from geometric future by a higher level in the hierarchy of conscious entities predicted by TGD! In long time scales we would be realizing our fates or wishes of higher level conscious entities rather than agents with completely free will.

2. The notion of magnetic body (MB) serving as a boss of ordinary matter would be central. MB carries dark matter as $h_{eff} = nh_0$ phases of ordinary matter with n serving as a measure for algebraic complexity of extension of rationals as its dimension and defining a kind of universal IQ. There is a hierarchy of these phases and MBs labelled by extension of rationals and the value of n.

   MBs would form a hierarchy of bosses - a realization for master slave hierarchy. Ordinary matter would be at the bottom and its coherent behavior would be induced from quantum coherence at higher levels. BSFR for higher level MB would give rise to what looks like planned actions and experienced as planned action at the lower levels of hierarchy. One could speak of planned actions inducing a cascade of planned actions in shorter time scales and eventually proceeding to atomic level.

A-8 Some notions relevant to TGD inspired consciousness and quantum biology

Below some notions relevant to TGD inspired theory of consciousness and quantum biology.

A-8.1 The notion of magnetic body

Topological field quantization inspires the notion of field body about which magnetic body is especially important example and plays key role in TGD inspired quantum biology and consciousness theory. This is a crucial departure fromt the Maxwellian view. Magnetic body brings in third level to the description of living system as a system interacting strongly with environment. Magnetic body would serve as an intentional agent using biological body as a motor instrument and sensory receptor. EEG would communicated the information from biological body to magnetic body and Libet's findings from time delays of consciousness support this view.

The following pictures illustrate the notion of magnetic body and its dynamics relevant for quantum biology in TGD Universe.

Fig. 18. Magnetic body associated with dipole field. `http://tgdtheory.fi/appfigures/fluxquant.jpg`

Fig. 19. Illustration of the reconnection by magnetic flux loops. `http://tgdtheory.fi/appfigures/reconnect1.jpg`

Fig. 20. Illustration of the reconnection by flux tubes connecting pairs of molecules. `http://tgdtheory.fi/appfigures/reconect2.jpg`

Fig. 21. Flux tube dynamics. a) Reconnection making possible magnetic body to "recognize" the presence of another magnetic body, b) braiding, knotting and linking of flux tubes making possible topological quantum computation, c) contraction of flux tube in phase transition reducing the value of h_{eff} allowing two molecules to find each other in dense molecular soup. `http://tgdtheory.fi/appfigures/fluxtubedynamics.jpg`

A-8.2 Number theoretic entropy and negentropic entanglement

TGD inspired theory of consciousness relies heavily p-Adic norm allows an to define the notion of Shannon entropy for rational probabilities (and even those in algebraic extension of rationals) by replacing the argument of logarithm of probability with its p-adic norm. The resulting entropy can be negative and the interpretation is that number theoretic entanglement entropy defined by this formula for the p-adic prime minimizing its value serves as a measure for conscious information. This negentropy characterizes two-particle system and has nothing to do with the formal negative negentropy assignable to thermodynamic entropy characterizing single particle. Negentropy Maximization Principle (NMP) implies that number theoretic negentropy increases during evolution by quantum jumps. The condition that NMP is consistent with the standard quantum measurement theory requires that negentropic entanglement has a density matrix proportional to unit matrix so that in 2-particle case the entanglement matrix is unitary.

Fig. 22. Schrödinger cat is neither dead or alive. For negentropic entanglement this state would be stable. `http://tgdtheory.fi/appfigures/cat.jpg`

A-8.3 Life as something residing in the intersection of reality and p-adicities

In TGD inspired theory of consciousness p-adic space-time sheets correspond to space-time correlates for thoughts and intentions. The intersections of real and p-adic preferred extremals consist of points whose coordinates are rational or belong to some extension of rational numbers in preferred embedding space coordinates. They would correspond to the intersection of reality and various p-adicities representing the "mind stuff" of Descartes. There is temptation to assign life to the intersection of realities and p-adicities. The discretization of the chart map assigning to real space-time surface its p-adic counterpart would reflect finite cognitive resolution.

At the level of "world of classical worlds" (WCW) the intersection of reality and various p-adicities would correspond to space-time surfaces (or possibly partonic 2-surfaces) representable in terms of rational functions with polynomial coefficients with are rational or belong to algebraic extension of rationals.

The quantum jump replacing real space-time sheet with p-adic one (vice versa) would correspond to a buildup of cognitive representation (realization of intentional action).

Fig. 23. The quantum jump replacing real space-time surface with corresponding p-adic manifold can be interpreted as formation of though, cognitive representation. Its reversal would correspond to a transformation of intention to action. `http://tgdtheory.fi/appfigures/padictoreal.jpg`

A-8.4 Sharing of mental images

The 3-surfaces serving as correlates for sub-selves can topologically condense to disjoint large space-time sheets representing selves. These 3-surfaces can also have flux tube connections and this makes possible entanglement of sub-selves, which unentangled in the resolution defined by the size of sub-selves. The interpretation for this negentropic entanglement would be in terms of sharing of mental images. This would mean that contents of consciousness are not completely private as assumed in neuroscience.

Fig. 24. Sharing of mental images by entanglement of subselves made possible by flux tube connections between topologically condensed space-time sheets associated with mental images. `http://tgdtheory.fi/appfigures/sharing.jpg`

A-8.5 Time mirror mechanism

Zero energy ontology (ZEO) is crucial part of both TGD and TGD inspired consciousness and leads to the understanding of the relationship between geometric time and experience time and how the arrow of psychological time emerges. One of the basic predictions is the possibiity of negative energy signals propagating backwards in geometric time and having the property that entropy basically associated with subjective time grows in reversed direction of geometric time. Negative energy signals inspire time mirror mechanism (see **Fig.** `http://tgdtheory.fi/appfigures/timemirror.jpg` or **Fig.** 24 in the appendix of this book) providing mechanisms of both memory recall, realization of intentational action initiating action already in geometric past, and remote metabolism. What happens that negative energy signal travels to past and is reflected as positive energy signal and returns to the sender. This process works also in the reverse time direction.

Fig. 25. Zero energy ontology allows time mirror mechanism as a mechanism of memory recall. Essentially "seeing" in time direction is in question. `http://tgdtheory.fi/appfigures/timemirror.jpg`

REFERENCES

Mathematics

[A1] Icosahedral graph. Wolfram MathWorld. Available at: `https://mathworld.wolfram.com/IcosahedralGraph.html`.

[A2] Why are there 1024 Hamiltonian cycles on an icosahedron? Available at: `https://tinyurl.com/pmghcwd`.

[A3] Yangian symmetry. Available at: `https://en.wikipedia.org/wiki/Yangian`.

[A4] Hopkins B. Hamiltonian paths on Platonic graphs. *IJMMS*, 30:1613–1616, 2004. Available at: `https://tinyurl.com/o84ahk6`.

[A5] Shipman B. Investigating bee behavior from the standpoint of fundamental physical principles. *Am Bee J*, 136(5):339–340, 1996.

[A6] Shipman B. The geometry of momentum mappings on generalized flag manifolds, connections with a dynamical system, quantum mechanics and the dance of honeybee, 1998. Available at: `https://math.cornell.edu/~oliver/Shipman.gif`.

[A7] Shipman B. On the geometry of certain isospectral sets in the full Kostant-Toda lattice., 1998. Available at: `https://nyjm.albany.edu:8000/PacJ/1997/Shipman.html`.

[A8] Shipman B. A symmetry of order two in the full Kostant-Toda lattice., 1998. Available at: `https://www.math.rochester.edu:8080/u/shipman/symmetrypaper/`.

[A9] Shipman B. The full Kostant -Toda lattice: Geometry of its singularities and its connection to honeybees and new developments in physics. 2007.

[A10] Shafarevich IR Borevich ZI. *Number Theory.* Academic Press, 1966.

[A11] Pope CN. Eigenfunctions and $Spin^c$ Structures on CP_2, 1980.

[A12] Freed DS. The Geometry of Loop Groups, 1985.

[A13] Hanson J Eguchi T, Gilkey B. *Phys Rep*, 66, 1980.

[A14] Eisenhart. *Riemannian Geometry.* Princeton University Press, 1964.

[A15] Pope CN Gibbons GW. CP_2 as gravitational instanton. *Comm Math Phys*, 55, 1977.

[A16] Pope CN Hawking SW. Generalized Spin Structures in Quantum Gravity. *Phys Lett*, (1), 1978.

[A17] N. Hitchin. Kählerian twistor spaces. *Proc London Math Soc*, 8(43):133–151, 1981.. Available at: `https://tinyurl.com/pb8zpqo`.

[A18] Milnor J. *Topology form Differential Point of View.* The University Press of Virginia, Virginia, 1965.

[A19] Spivak M. *Differential Geometry I,II,III,IV.* Publish or Perish, Boston, 1970.

[A20] Thom R. *Comm Math Helvet*, 28, 1954.

[A21] Helgason S. *Differential Geometry and Symmetric Spaces*. Academic Press, New York, 1962.

[A22] Wallace. *Differential Topology*. W. A. Benjamin, New York, 1968.

Theoretical Physics

[B1] Airy functions. Available at: `https://en.wikipedia.org/wiki/Airy_function`.

[B2] Chern-Simons theory. Available at: `https://en.wikipedia.org/wiki/Chern\OT1\textendashSimons_theory`.

[B3] Elitzur–Vaidman bomb-testing problem. Available at: `https://en.wikipedia.org/wiki/Elitzur\OT1\textendashVaidman_bomb-testing_problem`.

[B4] Montonen Olive Duality. Available at: `https://en.wikipedia.org/wiki/Montonen-Olive_duality`.

[B5] No-cloning theorem. Available at: `https://en.wikipedia.org/wiki/No_cloning_theorem`.

[B6] Das A. *Integrable Models*. World Scientific, 1989.

[B7] Zee A. *The Unity of Forces in the Universe*. World Sci Press, Singapore, 1982.

[B8] Lvovsky AI. Squeezed light, 2014. Available at:`https://arxiv.org/pdf/1401.4118v1.pdf`.

[B9] Drell S Björken J. *Relativistic Quantum Fields*. Mc Graw-Hill, New York, 1965.

[B10] Rapoport D. Stochastic processes in conformal Riemann-Cartan-Weyl gravitation, 1991. Available at: `https://link.springer.com/article/10.1007/BF00675614`.

[B11] Witten E Dolan L, Nappi CR. Yangian Symmetry in $D = 4$ superconformal Yang-Mills theory, 2004. Available at: `https://arxiv.org/abs/hep-th/0401243`.

[B12] Plefka J Drummond J, Henn J. Yangian symmetry of scattering amplitudes in $\mathcal{N} = 4$ super Yang-Mills theory, 2009. Available at: `https://cdsweb.cern.ch/record/1162372/files/jhep052009046.pdf`.

[B13] Arkani-Hamed N et al. The All-Loop Integrand For Scattering Amplitudes in Planar N=4 SYM, 2010. Available at: `https://arxiv.org/abs/1008.2958`.

[B14] Bose S et al. A Spin Entanglement Witness for Quantum Gravity, 2017. Available at: `https://arxiv.org/pdf/1707.06050.pdf`.

[B15] Minev ZK et al. To catch and reverse a quantum jump mid-flight, 2019. Available at: `https://arxiv.org/abs/1803.00545`.

[B16] Preskill J et al. Holographic quantum error-correcting codes: Toy models for the bulk/boundary correspondence, 2015. Available at: `https://arxiv.org/pdf/1503.06237.pdf`.

[B17] Wang Z Freedman M, Larsen H. A modular functor which is universal for quantum computation. *Comm Math Phys*, 1(2):605–622, 2002. Available at: `https://arxiv.org/abs/quant-ph/0001108`.

[B18] Parisi G. *Field Theory, Disorder and Simulations*. World Scientific, 1992.

[B19] Huang K. *Quarks,Leptons & Gauge Fields*. World Scientific, 1982.

[B20] Reshetikhin Yu Kulish P. *J Sov Math*, 23:2345, 1983.

Particle and Nuclear Physics

[C1] Kervran CL. *Biological transmutations, and their applications in chemistry, physics, biology, ecology, medicine, nutrition, agriculture, geology*. Swan House Publishing Co., 1972.

[C2] Samuel E. Ghost in the Atom. *New Scientist*, (2366):30, 2002.

[C3] Storms E. Cold fusion, an objective assessment, 2001. Available at: `https://home.netcom.com/~storms2/review8.html`.

[C4] Davies DT et al. Precise Charm to Strange Mass Ratio and Light Quark Masses from Full Lattice QCD. *Phys Rev*, 104, 2010. Available at: `https://prl.aps.org/abstract/PRL/v104/i13/e132003`.

[C5] Lobashev VM et al. In Maalampi J Enqvist K, Huitu K, editor, *Neutrino 96*, Singapore, 1996. World Scientific.

[C6] Shnoll SE et al. Realization of discrete states during fluctuations in macroscopic processes. *Usp Fis Nauk*, 41(10):1025–1035, 1998.

[C7] Weinheimer C et al. *Phys Lett B*, 300:210, 1993.

[C8] Stephenson GJJr. In Van Thanh JT et al, editor, *Perspectives in Neutrinos, Atomic Physics and Gravitation*, page 31. Editions Frontieres, Gif-sur-Yvette, 1993.

[C9] Bjorken JD. *Acta Phys Pol B*, 28:2773, 1997.

[C10] Collar JI. Endpoint Structure in Beta Decay from Coherent Weak-Interaction of the Neutrino, 1996. Available at: `https://arxiv.org/abs/hep-ph/9611420`.

[C11] McAlpine K. Incredible shrinking proton raises eyebrows, 2010. Available at: `https://tinyurl.com/3yf4n77`.

[C12] Bird C Tompkins P. *The secret life of plants*. Harper & Row, New York, 1973.

Condensed Matter Physics

[D1] Burning salt water. Available at: `https://www.youtube.com/watch?v=aGg0ATfoBgo`.

[D2] Copper. Available at: `https://en.wikipedia.org/wiki/Copper`.

[D3] High temperature and other unconventional superconductors. Available at: `https://www.fkf.mpg.de/metzner/research/hightc/hightc.html`.

[D4] Liquid crystals on line. Available at: `https://www.lcionline.net/`.

[D5] Percolation. Available at: `https://en.wikipedia.org/wiki/Percolation`.

[D6] Spontaneous burning. Available at: `https://tinyurl.com/nlj65la`.

[D7] Spontaneous human combustion. Available at: `https://tinyurl.com/jb5w`.

[D8] Scientists Detect 'Fingerprint' of High-temperature Superconductivity Above Transition Temperature. *Science Daily*, 2009. Available at: `https://www.sciencedaily.com/releases/2009/08/090827141338.htm`.

[D9] Hellemans A. Labs Hold the Key to the 21-Micrometer Mystery. *Science*, 284(5417):1113, 1999.

[D10] Li C. Optical Four-Wave Coupling Process. 2017. In: Nonlinear Optics. Springer, Singapore. `https://doi.org/10.1007/978-981-10-1488-8_4`.

[D11] Basov DN Carbotte J, Schachinger E. *Nature*, 401:354–356, 1999.

[D12] Springford M (ed). *Electron: A Centenary Volume.* Cambridge University Press, Cambridge, 1997.

[D13] Eck EJ. The first 200 K superconductor, 2015. Available at:`https://www.superconductors.org/400K_SC.htm`.

[D14] Tranquada JM Emery VJ, Kivelson SA. Stripe phases in high-temperature superconductors. *Perspective*, 96(16), 1999. Available at: `https://www.pnas.org/cgi/reprint/96/16/8814.pdf`.

[D15] Aoki D et al. Coexistence of super-conductivity and ferromagnetism in URhGe. *Nature*, 413, 2001.

[D16] Badoux S et al. Change of carrier density at the pseudogap critical point of a cuprate superconductor. *Nature*, 2016. Available at:`https://tinyurl.com/go9k8cs`.

[D17] Bozovic I et al. Temporal correlations of superconductivity above the transition temperature in la2 xsrxcuo4 probed by terahertz spectroscopy. *Nature Physics*, 7:298 302, 2011. Available at:`https://tinyurl.com/hk88h5w`.

[D18] Bozovic I et al. Dependence of the critical temperature in overdoped copper oxides on superfluid density. *Nature*, 536:309–311, 2016. Available at:`https://tinyurl.com/gqo9j67`.

[D19] Camargo F et al. Creation of Rydberg Polarons in a Bose Gas. *Nature*, 2018. Available at: `https://arxiv.org/pdf/1706.03717.pdf`..

[D20] Cao Y et al. Correlated insulator behaviour at half-filling in magic-angle graphene superlattices. *Nature*, 2018. Available at: `https://dx.doi.org/10.1038/nature26154`..

[D21] Cao Y et al. Unconventional superconductivity in magic-angle graphene superlattices. *Nature*, 2018. Available at: `https://dx.doi.org/10.1038/nature26160`..

[D22] Castleman AW et al. Al Cluster Superatoms as Halogens in Polyhalides and as Alkaline Earths in Iodide Salts. *Science*, 307, 2005.

[D23] Chatterjee S et al. Lifshitz transition from valence fluctuations in YbAl3. *Nature Communications*, 8(852), 2017. Available at: `https://www.nature.com/articles/s41467-017-00946-1`.

[D24] Fong HS et al. *Phys Rev*, 75, 1995.

[D25] Gammaitoni L et al. Stochastic Resonance. *Rev Mod Phys* ., 70, 1998.Available at: `https://www.umbrars.com/sr/`.

[D26] Gingras JP et al. Nematicity in stripe-ordered cuprates probed via resonant x-ray scattering. *Science*, 351(6273), 2016. Available at:`https://tinyurl.com/zycahrx`.

[D27] Hua R-H et al. From a Single-Band Metal to a High-Temperature Superconductor via Two Thermal Phase Transitions. *Science*, 331(6024):1579–1583, 2011. Available at: `https://www.sciencemag.org/content/331/6024/1579.abstract`.

[D28] Jaramillo R et al. Origins of bad-metal conductivity and the insulator-metal transition in the rare-earth nickelates. *Nature Physics*, 10:304–307, 2014.

[D29] Knight WD et al. *Phys Rev*, 52, 1984.

[D30] Levy F et al. Magnetic Field-Induced Super-conductivity in the Ferromagnet URhGe. *Science*, August 2005.

[D31] Lin X et al. Beating the thermodynamic limit with photo-activation of n-doping in organic semiconductors. *Nature Materials*, 16:1209–1215, 2017.Available at: `https://www.nature.com/articles/nmat5027`.

[D32] Magnuson M et al. Self-doping processes between planes and chains in the metal-to-superconductor transition of yba2cu3o6.9. *Nature. Scientific Reports*, 4(7017), 2014. Available at:`https://tinyurl.com/zvfhqu2`.

[D33] Mathur ND et al. Magnetic superglue promotes super-conductivity. *Physics Web*, 1998.Available at: `https://physicsweb.org/articles/news/2/7/3`.

[D34] Mills R et al. Spectroscopic and NMR identification of novel hybrid ions in fractional quantum energy states formed by an exothermic reaction of atomic hydrogen with certain catalysts, 2003. Available at: `https://www.blacklightpower.com/techpapers.html`.

[D35] Moock HA et al. *Phys Rev*, 70, 1993.

[D36] Moreh R et al. Search for anomalous scattering of keV neutrons from H2O-D2O mixtures. *Phys Rev*, 94, 2005.

[D37] Morris DJ et al. Dirac Strings and Magnetic Monopoles in Spin Ice Dy2Ti2O7. *Physics World*, 326(5951):411–414, 2009.Available at: `https://physicsworld.com/cws/article/news/40302`.

[D38] Orenstein J et al. In *Electronic properties of high T_c super conductors*, pages 254–259, Berlin, 1990. Springer.

[D39] Persky E et al. Magnetic memory and spontaneous vortices in a van der Waals superconductor. *Nature*, 2022. Available at: `https://arxiv.org/pdf/2206.07730.pdf`.

[D40] Rosenthal EP et al. Visualization of electron nematicity and unidirectional antiferroic fluctuations at high temperatures in NaFeAs. *Nature Physics*, 10:225 232, 2014. Available at:`https://www.nature.com/nphys/journal/v10/n3/full/nphys2870.html`.

[D41] Rossat-Mignot J et al. *Phys Rev*, 235:59, 1994.

[D42] Sebastian SE et al. Unconventional fermi surface in an insulating state. *Science*, 349(6243):605–607, 2015. Available at: `ttps://en.wikipedia.org/wiki/Pi_bond`.

[D43] Winterer G et al. Cortical activation, signal-to-noise ratio and stochastic resonance during information processing in man. *Clin Neurophysiol J*, 110(7):1193–203, 1999.

[D44] Wollman DA et al. Experimental determinination of the super-conducting pairing state in YBCO from the phase coherence of YBCO-Pb dc SQUIDs. *Phys Rev*, 71, 1993.

[D45] Boudin A Flouquet J. Ferromagnetic super-conductors. *Physics Web*, 2002. Available at: `https://physicsweb.org/articles/world/15/1/9`.

[D46] Hofman DM Hartnoll SA. Generalized lifshitz-kosevich scaling at quantum criticality from the holographic correspondence. *Phys Rev B*, 81(151125), 2010. Available at: `https://journals.aps.org/prb/abstract/10.1103/PhysRevB.81.155125`.

[D47] Langmuir I. *J Am Chem Soc*, 37, 1915.

[D48] Morgenstern I. *Spin-Glass behavior of high T_c super conductors*. Springer Verlag, 1990.

[D49] Kostadinov IZ. 373 K Superconductors, 2016. Available at:`https://arxiv.org/pdf/1603.01482v1.pdf`.

[D50] Orenstein J. High-temperature superconductivity: Electrons pair themselves. *Nature*, 401:333–335, 1999.

[D51] Zaanen J. Why high Tc is exciting?, 2005. Available at: `https://www.lorentz.leidenuniv.nl/research/jan_hitc.pdf`.

[D52] Zaanen J. Superconductivity: Quantum Stripe Search. *Nature*, 2006. Available at: `https://www.lorentz.leidenuniv.nl/~jan/nature03/qustripes06.pdf`.

[D53] Zaanen J. Superconductivity: Quantum Stripe Search. *Nature*, 2006. Available at: `https://www.lorentz.leidenuniv.nl/~jan/nature03/qustripes06.pdf`.

[D54] Zaanen J. Watching Rush Hour in the World of Electrons. *Science*, 2007. Available at: `https://www.ilorentz.org/~jan/perspstripes.pdf`.

[D55] Borchardt JK. The chemical formula H2O - a misnomer. *Alchemist*, August 2003.

[D56] Ross DK Li J-C. Evidence of Two Kinds of Hydrogen Bonds in Ices. *Nature*, 365:327–329, 1993.

[D57] Buchanan M. Mind the pseudogap. *Nature*, 409:8–11, 2001.Available at: `https://www.physique.usherbrooke.ca/taillefer/Projets/Nature-409008.pdf`.

[D58] Chaplin M. Water Structure and Behavior, 2005. Available at: `https://www.lsbu.ac.uk/water/index.html`. For the icosahedral clustering see `https://www.lsbu.ac.uk/water/clusters.html`.

[D59] Rabinowitz M. Phenomenological Theory of Superfluidity and Super-conductivity, 2001. Available at: `https://arxiv.org/abs/cond-mat/0104/0104059`.

[D60] Ho M-W. Can Water burn, 2009. Available at: `https://www.i-sis.org.uk/canWaterBurn.php`.

[D61] Ho M-W. Living with Oxygen, 2009. Available at: `https://www.i-sis.org.uk/livingWithOxygen.php`.

[D62] Ho M-W. Making Fuel from Water . *Institute of Sci in Soc report.*, 2009. Available at: `https://www.i-sis.org.uk/makingFuelFromWater.php`.

[D63] Ho M-W. The body does burn water, 2009. Available at: `https://www.i-sis.org.uk/theBodyDoesBurnWater.php`.

[D64] Ho M-W. Water electric. *Institute of Sci in Soc report*, 2009.Available at: `https://www.i-sis.org.uk/WaterElectric.php`.

[D65] Ball P. A new kind of alchemy. *New Scientist*, 2005. Available at: `https://www.newscientist.com/channel/fundamentals/mg18624951.800`.

[D66] Qing Z Pollack G, Figueroa X. Molecules, water and radiant energy: new clues for the origin of life. *Int J Mol Sci*, 10(4):1419–29, 2009.

[D67] Anderson PW. *Rev Mod Phys*, 38, 1966.

[D68] Cowley RA. Neutron-scattering experiments and quantum entanglement. *Phys B*, 350:243–245, 2004.

[D69] Sachdev S. Quantum phase transitions (summary). *Physics World*, pages 33–38, April 1999.

[D70] Batlogg B et al Schön JH, Kloc C. Super-conductivy in molecular crystals induced by charge injection. *Nature*, 406, August 2000.

[D71] Tilley K Tilley DR. *Super Fluidity and Super Conductivity*. Adam Hilger Ltd, 1986.

[D72] Pollack G Zheng J-M. Long-range forces extending from polymer-gel surfaces, 2003. Available at: `https://arxiv.org/abs/cond-mat/0305093`.

Cosmology and Astro-Physics

[E1] Webb JK Barrow JD. Inconstant Constants: Do the inner workings of nature change with time? *Sci Am*, 2005. Available at: `https://tinyurl.com/bl969`.

[E2] Nottale L Da Rocha D. Gravitational Structure Formation in Scale Relativity, 2003. Available at: `https://arxiv.org/abs/astro-ph/0310036`.

[E3] Freeman PE et al. Examining the Effect of the Map-making Algorithm on Observed Power Asymmetry in WMAP Data. *Astrophys J*, 638, 2006. Available at: `https://arxiv.org/abs/astro-ph/0510406`.

[E4] Linden T et al. *Evidence for a New Component of High-Energy Solar Gamma-Ray Production*, 2019. Available at:`https://arxiv.org/abs/1803.05436`.

[E5] Nisa MU et al. *The Sun at GeV–TeV Energies: A New Laboratory for Astroparticle Physics*, 2019.Available at:`https://arxiv.org/abs/1903.06349`.

[E6] Shnoll SE et al. Realization of discrete fluctuations in macroscopic processes. *Physics-Uspekhi*, 41(10):1025–1035.

[E7] Tajmar M et al. Experimental Detection of Gravimagnetic London Moment, 2006. Available at: `https://arxiv.org/abs/gr-gc0603033`. See also the popular article "Towards new tests of general relativity", at `https://www.esa.int/SPECIALS/GSP/SEM0L60VGJE_0.html`.

[E8] Tate J et al. *Phys Rev*, 62(8), 1989.

[E9] Matos de CJ Tajmar M. Local Photon and Graviton Mass and Its Consequences, 2006. Available at: `https://arxiv.org/abs/gr-gc0603032`.

Physics of Earth

[F1] Anaerobic bacteria. Available at: `https://en.wikipedia.org/wiki/Anaerobic_bacteria`.

[F2] Saleh A. Capturing the Earth's songs. *ABC Science Online*, 2001. Available at: `https://www.abc.net.au/science/news/stories/s237849.htm`.

[F3] Sentman DD. *Schumann Resonances*, volume 1, pages 267–295. Boca Raton: CRC Press, 1995.

[F4] Zgrablic G et al. Instrumental recording of electrophonic sounds from Leonid fireballs. *J. Geophys Res*, 2001. Available at: `https://fizika.org/ilwcro/results/`.

[F5] Elert G. Electric Field on Earth. Available at: `https://hypertextbook.com/facts/1998/TreshaEdwards.shtml`, 2005.

[F6] Hecht J. The Giant Crystal at the Heart of the Earth. *New Scientist*, page 17, 1994.

[F7] Hansen TL. The northern lights-what are they?, 2001. Available at: `https://geo.phys.uit.no/articl/theaurora.html`.

Fringe Physics

[H1] M. B. King. Free-energy devices. Available at: `https://www.free-energy-info.co.uk/MorayKing.pdf`.

[H2] Fernandez J Armada F. *Extraterrestrial Intervention in Fatima –the Apparitions and the UFO phenomena*. Amadora, Livraria Bertrand, 1982.

[H3] Hudson D. Mono-atomic elements, 2003. Available at: `https://www.halexandria.org/dward479.htm`.

[H4] Urutskoev LI et al. Observation of transformation of chemical elements during electric discharge. *Ann. Fond. L. de Broglie*, 27(701), 2002. Available at: `https://arxiv.org/abs/arXiv:physics/0101089`.

[H5] Hutchison J. The Hutchison Effect Apparatus. *Proc first Symposium on New Energy, Denver, May*, 199, 1994.

[H6] Naudin J. Free Energy Atomic Hydrogen: the MAHG project, 2005. Available at: `https://jlnlabs.imars.com/mahg/tests/index.htm`.

[H7] Jochmans JR. Strange Relics from the Depths of the Earth, 1979. Available at: `https://www.delusionresistance.org/creation/antedeluvian_finds.html`.

[H8] Fredericks KA. Possible detection of tachyon monopoles in photographic emulsions. *justsomething*, 2013. Available at: `https://restframe.com/downloads/tachyon_monopoles.pdf`.

[H9] King MB. Water Electrolyzers and the Zero-Point Energy. *Phys Procedia*, 20:335–445, 2011. Available at: `https://www.sciencedirect.com/science/journal/18753892`.

[H10] Mignani R Recami E. Classical theory of tachyons (special relativity extended to superluminal frames and objects). *Nuovo Cimento*, 4(209):209–290, 1974.

[H11] Corliss W. Ancient Man: A Handbook of Puzzling Artifacts, 1978. Available at: `https://www.miqel.com/text/tcookie.html`.

Biology

[I1] Alpha helix. Available at: https://en.wikipedia.org/wiki/Alpha_helix.

[I2] Asparagine Synthetase. Available at: https://www.pdb.org/pdb/files/11as.pdb.

[I3] ATP hydrolysis. Wikipedia article.Available at: https://en.wikipedia.org/wiki/ATP_hydrolysis.

[I4] Bamhi. Available at: https://www.rcsb.org/pdb/files/1bam.pdb.

[I5] Bamhi. Available at: https://rebase.neb.com/cgi-bin/seqsget?X55285.

[I6] Beta sheet. Available at: https://en.wikipedia.org/wiki/Beta_sheet.

[I7] Biophotons. Available at: https://en.wikipedia.org/wiki/Biophotons.

[I8] Brief introduction into WaveGenetics. Its scope and opporturnities. Available at: https://www.wavegenetics.jino-net.ru.

[I9] Collagen. Available at: https://en.wikipedia.org/wiki/Collagen.

[I10] DNA replication. Available at: https://en.wikipedia.org/wiki/DNA_replication.

[I11] Everywhere in a Flash: The Quantum Physics of Photosynthesis. Available at: https://www.wired.com/wiredscience/2010/02/quantum-photosynthesis/.

[I12] Fertilization. Available at: https://en.wikipedia.org/wiki/Fertilization.

[I13] Free radical theory. Available at: https://en.wikipedia.org/wiki/Free-radical_theory. See also *Free radicals and your health* t https://www.healingdaily.com/conditions/free-radicals.htm..

[I14] Genetic code. Available at: https://en.wikipedia.org/wiki/Genetic_code.

[I15] Glutathione S-transferase. Available at: https://www.pdb.org/pdb/files/14gs.pdb.

[I16] Homeopathy. Available at: https://en.wikipedia.org/wiki/Homeopathy.

[I17] Hydrolase(O-glycosyl). Available at: https://www.pdb.org/pdb/files/107l.pdb.

[I18] M. Emoto. Available at: https://www.i-sis.org.uk/water4.php.

[I19] Meiosis. Available at: https://en.wikipedia.org/wiki/Meiosis.

[I20] Mitosis. Available at: https://en.wikipedia.org/wiki/Mitosis.

[I21] Phospholipids. Available at: https://en.wikipedia.org/wiki/Phospholipids.

[I22] Pollack Laboratory- Biographical Sketch. Available at: https://faculty.washington.edu/ghp/cv/.

[I23] Polymerase chain reaction. Available at: https://en.wikipedia.org/wiki/PCR.

[I24] Protein aggregation. Available at: https://en.wikipedia.org/wiki/Protein_aggregation.

[I25] 'Psychic cells': Scientists discover cells can communicate through physical barriers. Available at: `https://newsroom.ucla.edu/portal/ucla/ucla-drew-scientists-undercover-243053.aspx`.

[I26] Quantum Mechanics Boosts Photosynthesis. Available at: `https://physicsworld.com/cws/article/news/41632`.

[I27] Secondary structures. Available at: `https://en.wikipedia.org/wiki/Secondary_structure`.

[I28] The 20 amino-acids. Available at: `https://www.people.virginia.edu/~rjh9u/aminacid.html`.

[I29] Untangling the Quantum Entanglement Behind Photosynthesis: Berkeley scientists shine new light on green plant secrets. Available at: `https://newscenter.lbl.gov/feature-stories/2010/05/10/untangling-quantum-entanglement/`.

[I30] Water has memory. Available at: `https://www.youtube.com/watch?v=ILSyt_Hhbjg`.

[I31] Xylose Isomerase. Available at: `https://www.pdb.org/pdb/files/1a0c.pdb`.

[I32] Dr. Phil Callahan on Power of Paramagnetism. *Nexus*, 2003. Available at: `https://www.nexusmagazine.com`.

[I33] Acupuncture's Molecular Effects Pinned Down: New Insights Spur Effort to Boost Treatment's Impact Significantly, 2010. Science News: `https://www.sciencedaily.com/releases/2010/05/100530144021.htm`.

[I34] Unusual Quantum Effect Discovered in Earliest Stages of Photosynthesis. *Science News*. Available at: `https://www.sciencedaily.com/releases/2012/05/120524092932.htm`, 2012.

[I35] The Fourth Phase of Water: Dr. Gerald Pollack at TEDxGuelphU, 2014. Available at: `https://www.youtube.com/watch?v=i-T7tCMUDXU`.

[I36] Sivadasan VA Bajpai RP, Kumar S. Biophoton emission on the evolution of squeezed state of frequency stable damped oscillator. *Appl Math & Comput*, 93:277–288, 1998.

[I37] Bajpai BP. Coherent nature of the radiation emitted in delayed luminescence of leaves. *J Theor Biol*, 1999.

[I38] Smith C. *Learning From Water , A Possible Quantum Computing Medium*. CHAOS, 2001.

[I39] Ingalls CE. Sensation of Hearing in Electromagnetic Fields, 2002. Available at: `https://www.angelfire.com/or/mctrl/ingalls.htm`.

[I40] McMenamin PG Chinnery HR, Pearlman E. Cutting Edge: Membrane Nanotubes In Vivo: A Feature of MHC Class II+ Cell s in the Mouse Cornea. *J Immunol*, 180:5779–5783, 2008.

[I41] Murogoki P Comorosan S, Hristea M. On a new symmetry in biological systems. *Bull Math Biol*, page 107, 1980.

[I42] Rodgers CT and Hore PJ. Chemical magnetoreception in birds: The radical pair mechanism. *PNAS*, 106:353–360, 2016. Available at: `https://tinyurl.com/zsg4b95`.

[I43] Robson D. Researchers Seek to Demystify the Metabolic Magic of Sled Dogs, 2008. Available at: `https://tinyurl.com/o4o8srm`.

[I44] Woodbury DJ. Pure lipid vesicles can induce channel-like conductances in planar bilayers., 1989.

[I45] Clayton DL. Circadian and geotactic behaviors: Genetic pleiotropy in *drosophila melanogaster*. *Journal of Circadian Rhytms*, 12(1):1–5, 2016. Available at: `https://dx.doi.org/10.5334/jcr.140`.

[I46] Tedeschi Alberto Emilio Del Giudice, Paola Rosa Spinetti. Article: Water Dynamics at the Root of Metamorphosis in Living Organisms. *Water*, 2:566–586, 2010. Available at: `https://www.mdpi.com/journal/water`.

[I47] Alberts B et al. *Mol Biol Cell* . Garland Publishing, Inc., London, 1989.

[I48] Benveniste J et al. Human basophil degranulation triggered by very dilute antiserum against IgE. *Nature*, 333:816–818, 1988.

[I49] Benveniste J et al. Transatlantic transfer of digitized antigen signal by telephone link. *J Allergy and Clinical Immunology*, 99:175, 1989. Available at: `https://www.digibio-.com/`.

[I50] Bonora M et al. ATP synthesis and storage. *Purinergic Signal*, 8(3):343–357, 2012. Available at: `https://pubmed.ncbi.nlm.nih.gov/22528680/`.

[I51] Diaz-Colunga J et al. Global epistasis on fitness landscapes. *Philosophical Transactions of the Royal Society B. Biological Sciences*, 2023. Available at: `https://doi.org/10.1098/rstb.2022.0053`.

[I52] Dotta BT et al. Biophoton emissions from cell cultures: biochemical evidence for the plasma membrane as the primary source. *Gen Physiol Biophys*, 30(3):301–309, 2011.

[I53] Gariaev P et al. *The DNA-wave biocomputer*, volume 10. CHAOS, 2001.

[I54] Gariaev PP et al. Holographic Associative Memory of Biological Systems. *Proceedings SPIE - The International Soc for Opt Eng . Optical Memory and Neural Networks*, pages 280–291, 1991.

[I55] Gariaev PP et al. The spectroscopy of bio-photons in non-local genetic regulation. *J Non-Locality and Remote Mental Interactions*, (3), 2002. Available at: `https://www.emergentmind.org/gariaevI3.htm`.

[I56] Goldman N et al. Adenosine A1 receptors mediate local anti-nociceptive effects of acupuncture. *Nature Neuroscience*, 13:883–888, 2010. . Available at: `https://www.nature.com/neuro/journal/v13/n7/full/nn.2562.html`.

[I57] Haussmann IU et al. CMTr cap-adjacent 2'-O-ribose mRNA methyltransferases are required for reward learning and mRNA localization to synapses. *Nature Communications*, 13(1), 2022. Available at: `https://www.nature.com/articles/s41467-022-28549-5`.

[I58] Kataoka Y et al. Activity-Dependent Neural Tissue Oxidation Emits Intrinsic Ultraweak Photons. *Biochem & Biophys Res Comm*, 285(4):1007–1011, 2001.

[I59] Kazumov AYu et al. Proximity-Induce super-conductivity in DNA. *Science*, 291, 2001.

[I60] Klumpe H et al. The context-dependent, combinatorial logic of BMP signaling, 2020. Available at: `https://www.biorxiv.org/content/10.1101/2020.12.08.416503v1`.

[I61] Krasnokutski et al. A pathway to peptides in space through the condensation of atomic carbon, 2022. Available at: `https://arxiv.org/abs/2202.12170`.

[I62] Lev AA et al. Rapid switching of ion current in narrow pores: implications for biological ion channels. *Proc R Soc London. Series B: Biological Sci s*, pages 187–192, 1993.

[I63] Lin JC et al. The Micro-wave Auditive phenomenon. *Proceedings of the IEEE*, 68, 1980.

[I64] Ling GN et al. Experimental confirmation, from model studies, of a key prediction of the polarized multilayer theory of cell water. *Physiological Chem & Phys*, 10(1):87–88, 1978.

[I65] Montagnier L et al. Electromagnetic Signals Are Produced by Aqueous Nanostructures Derived from Bacterial DNA Sequences. *Interdiscip Sci Comput Life Sci* . Available at: `https://www.springerlink.com/content/0557v31188m3766x/`, 2009.

[I66] Montagnier L et al. DNA waves and water, 2010. Available at: `https://arxiv.org/abs/1012.5166`.

[I67] Montagnier Y et al. Water Bridging Dynamics of Polymerase Chain Reaction in the Gauge Theory Paradigm of Quantum Fields. *Water*, 9(5), 2017. Available at: `https://www.mdpi.com/2073-4441/9/5/339`.

[I68] Perry et al. Mitochondrial membrane potential probes and the proton gradient: a practical usage guide. *BioTechniques*, 50(2), 2018. Available at: `https://www.future-science.com/doi/10.2144/000113610`.

[I69] Pezo V et al. Noncanonical DNA polymerization by aminoadenine-based siphoviruses. *Science*, 372(6541), 2021. Available at: `https://www.science.org/doi/10.1126/science.abe6542`.

[I70] Popp et al. Biophoton emission. New evidence for coherence and DNA as source. *Biophys*, 6(1):33–52, 1984.

[I71] Popp F-A et al. Emission of Visible and Ultraviolet Radiation by Active Biological Systems. *Collective Phenomena*, 3, 1981.

[I72] Popp F-A et al. Physical aspects of biophotons. *Experientia*, 44(7):576–585, 1988.

[I73] Popp F-A et al. Evidence of non-classical (squeezed) light in biological systems. *Phys Lett A*, 293(4):98–102, 2002.

[I74] Purves D et al. *What are basal ganglia?* 2001. August. Available at: `https://www.neuroscientificallychallenged.com/blog/what-are-basal-ganglia`.

[I75] Rahnama M et al. Emission of mitochondrial biophotons and their effect on electrical activity of membrane via microtubules. *J Integr NeuroSci* . Available at: `https://arxiv.org/pdf/1012.3371.pdf`, 1:65–88, 2009.

[I76] Sataric MV et al. Modelling the role of intrinsic electric fields in microtubules as an additional control mechanism of bi-directional intracellular transport. *Biochem Biophys*, 52:113–124, 2008.

[I77] Steinier YR et al. Genetic compensation induced by deleterious mutations but not gene knockdowns. *Nature*, 2015. Available at: `https://doi.org/10.1038/nature14580`.

[I78] Vaibhav Mohanty et al. Maximum mutational robustness in genotype–phenotype maps follows a self-similar blancmange-like curve. *Journal of The Royal Society Interface*, 2023. Available at: `rebrand.ly/zrzfgoy`.

[I79] Wang Z et al. Human high intelligence is involved in spectral redshift of biophotonic activities in the brain. *Proc Nat Acad Sci of USA*, 2016. Available at: `https://tinyurl.com/j5vusyy`.

[I80] Yoshii T et al. Cryptochrome mediates light-dependent magnetosensitivity of drosophila's circadian clock. *PLoS Biol*, 7(4), 2009. Available at: `https://tinyurl.com/zvlmxp6`.

[I81] Zerulla K et al. Dna as a phosphate storage polymer and the alternative advantages of polyploidy for growth or survival. *PLOS one*, 9(4), 2014.

[I82] Zhang Y et al. The radical pair mechanism and the avian chemical compass: Quantum coherence and entanglement, 2015. Available at: `https://tinyurl.com/zvcguuz`..

[I83] Popp F-A. Properties of biophotons and their theoretical implications. *Indian J Exp Biol*, 41(5):391–402, 2003.

[I84] Popp FA. Electronic structure and carcinogenic activity of 3,4-benzopyrene and 1,2-benzopyrene. *Z Naturforsch B.*, 27(7):850–863, 1972.

[I85] Popp FA. Cancer growth and its inhibition in terms of coherence. *Electromagn Biol Med*, 28(1):53–60, 2009.

[I86] Schönenberger C Fink H-W. Electrical conduction through DNA molecules. *Nature*, 398, 1999.

[I87] Cheng Y-C Fleming GR, Lee H. Coherence Dynamics in Photosynthesis: Protein Protection of Excitonic Coherence. *Science*, 316(5830):1462–1465, 2007. Available at: `https://www.nature.com/ejhg/journal/v10/n11/index.html`.

[I88] Bludorf F Fozar G. Scientists prove DNA Can Be Reprogrammed by Words and Frequencies, 2014.

[I89] Ling G. Three sets of independent disproofs against the membrane-pump theory, 1978. Available at: `https://www.gilbertling.org/lp6a.htm`.

[I90] Ling G. Oxidative phosphorylation and mitochondrial physiology: a critical review of chemiosmotic theory and reinterpretation by the association-induction hypothesis. *Physiol. Chem. & Physics*, 13, 1981.

[I91] Pollack G. *Cells, Gels and the Engines of Life.* Ebner and Sons, 2000. Available at: `https://www.cellsandgels.com/`.

[I92] Pollack G. *Cells, Gels and the Engines of Life.* Ebner and Sons, 2000. Available at: `https://www.cellsandgels.com/`.

[I93] Vassilatos G. Nocturnal Disturbances and the Infrasonic "HUM", 2001. Available at: `https://www.borderlands.com/journal/nux.htm`.

[I94] Maslow MU Gariaev PP. Fractal Presentation of Natural Language Texts and Genetic Code, 2nd International Conference on Quantitative Linguistics. *QUALICO '94*, pages 193–194, 1994.

[I95] Tovmash AV Gariaev PP, Tertishni GG. Experimental investigation in vitro of holographic mapping and holographic transposition of DNA in conjuction with the information pool encircling DNA. *New Medical Technologies*, 9:42–53, 2007.

[I96] Ling GN. *A physical theory of the living state: the association-induction hypothesis; with considerations of the mechanics involved in ionic specificity.* Blaisdell Pub. Co., New York, 1962.

[I97] Ling GN. Maintenance of low sodium and high potassium levels in resting muscle cells. *J Physiol (Cambridge)*, pages 105–123, 1978.

[I98] Turberfield J A Green SJ, Lubrich D. DNA Hairpins: Fuel for Autonomous DNA Devices. *Biophys J*, 2006. Available at: `https://findarticles.com/p/articles/mi_qa3938/is_200610/ai_n16779588/pg_1`.

[I99] Burr H. *The fields of life.* New York: Ballantine, 1972.

[I100] Fröhlich H. The extraordinary dielectric properties of biological materials and the action of enzymes. *Nature*, 72(1968):641–649, 1975.

[I101] Mae-Wan Ho. Super-Conducting Liquid Crystalline Water Aligned with Collagen Fibres in the Fascia as Acupuncture Meridians of Traditional Chinese Medicine. *Forum on immunopathological diseases and therapeutics*, 3(3-4):221–236, 2012. Available at: `https://dl.begellhouse.com/journals/1a654bf03faf67ac,744ec0d724b32947.html`.

[I102] Saunders PT Ho M-W. *Liquid Crystalline Mesophase in living organisms.* World Scientific, Singapore, 1994.

[I103] Kominis IK. The radical-pair mechanism as a paradigm for the emerging science of quantum biology, 2015. Available at: `https://arxiv.org/abs/1512.00450.`.

[I104] Slavinski J. Biophotons from stressed and dying organisms: toxicological aspects. *Indian J Exp Biol*, 41(5):483–493, 2003.

[I105] Brizhik L. Nonlinear mechanism for weak photon emission from biosystems. *Indian J Exp Biol*, 46(5):353–357, 2008.

[I106] McTaggart L. *The Field*. HarperCollinsPublishers Ltd. Available at: `https:/www.torsioelement.com.`, 2001.

[I107] Sanduloviciu M Lozneanu E. Minimal-cell system created in laboratory by self-organization. *Chaos , Solitons & Fractals*, 18(2):335, 2003. See also *Plasma blobs hint at new form of life*. New Scientist vol. 179, No. 2413 p. 20 September 2003, page 16.

[I108] Buchanan M. Shape is all. *New Scientist*, 2157, 1998.

[I109] Emoto M. *Crystal Clear – Messages from Water*. Beyond Worlds, 2005. Available at: `https://www.libristo.eu/en/book/hidden-messages-in-water_09269861`.

[I110] Levin M. The wisdom of the body: future techniques and approaches to morphogenetic fields in regenerative medicine, developmental biology and cancer. *Regen Med* . Available at: `https://www.futuremedicine.com/doi/pdf/10.2217/rme.11.69`, 6(6):667–673, 2011.

[I111] Levin M. Morphogenetic fields in embryogenesis, regeneration, and cancer: Non-local control of complex patterning. *Biosystems*, 109(3):243–261, 2012. Available at: `https://www.ncbi.nlm.nih.gov/pubmed/22542702`.

[I112] Ho M-W. *The Rainbow and the Worm*. World Scientific, Singapore, 1993.

[I113] Ho M-W. Genes don't Generate Body Patterns, 2011. Available at: `https://www.i-sis.org.uk/Genes_dont_Generate_Body_Patterns.php`.

[I114] Ho M-W. Mystery of Missing Heritability Solved, 2011. Available at: `https://www.i-sis.org.uk/Mystery_of_Missing_Heritability_Solved.php`.

[I115] Ho M-W. No Genes for Intelligence in the Human Genome, 2011. Available at: `https://www.i-sis.org.uk/No_Genes_for_Intelligence_in_the_Human_Genome.php`.

[I116] Ho M-W. Proteins secret water music in nanospace, 2011. Available at: `https://www.i-sis.org.uk/Proteins_secret_water_music_in_nanospace.php`.

[I117] Ho M-W. Quantum Coherent Water Homeopathy, 2011. Available at: `https://www.i-sis.org.uk/Quantum_Coherent_Water_Homeopathy.php`.

[I118] Volodyaev Ilya Mayburov SN. Photons Production and Communications in Biological Systems. *Progress In Electromagnetics Research Symposium Abstracts*, 2009.

[I119] Stevens MJ. Simple Simulations of DNA Condensation. *Biophys. J.*, 80(1):130–139, 2001. Available at: `https://www.biophysj.org/cgi/content/full/80/1/130#E8`.

[I120] Volkenstein MV. *Biophysics*. Mir Publishers, Moscow, 1983.

[I121] Ho MW. *The Rainbow and the Worm*. World Scientific, Singapore, 1993.

[I122] Rattemayer M Nagl W, Popp F-A. Evidence of Photon Emission from DNA in Living Systems. *Naturwissenschaften*, 68(5):577, 1981.

[I123] Nwamba OC. Membranes as the third genetic code. *Mol Biol Rep*, 47(5):4093–4097, 2020. Available at: `https://pubmed.ncbi.nlm.nih.gov/32279211/`.

[I124] Gariaev P. Materialization of DNA Fragment and Wave Genetics in Theory and Practice. *DNADJ*, 4(1), 2014. Available at: `https://www.amazon.com/Decipher-Journal-Volume-Issue-Materialization/dp/1500127493`.

[I125] England J Perunov N, Marsland R. Statistical Physics of Adaptation, 2014. Available at: `https://arxiv.org/pdf/1412.1875v1.pdf`.

[I126] Zhao Q Pollack GH, Figueroa X. Molecules, water, and radiant energy: new clues for the origin of life. *Int J Mol Sci*, 10:1419–1429, 2009. Available at: `https://tinyurl.com/ntkfhlc`.

[I127] Callahan PS. Moth and Candle: the Candle Flame as a Sexual Mimic of the Coded Infrared Wavelengths from a Moth Sex Scent. *Appl Opt*, 16(12), 1977.

[I128] Orians GH Purves WK. *Life: The Sci of Biology*. Sinauer, Massachusetts, 1987.

[I129] Sheldrake R. *A New Science of Life: The Hypothesis of Formative Causation*. Inner Traditions Intl Ltd., 1995.

[I130] Sheldrake R. *The Presence of Past: Morphic Resonance and the Habits of Nature* . Icon Books Ltd, 2011.

[I131] Pospisil P Rastogi A. Effect of exogenous hydrogen peroxide on biophoton emission from radish root cells. *Plant Physiol & Biochem*, 48:117–123, 2010.

[I132] Pospisil P Rastogi A. Ultra-weak photon emission as a non-invasive tool for monitoring of oxidative processes in the epidermal cells of human skin: comparative study on the dorsal and palm side of the hand. *Skin Res & Tech*, 16:365–370, 2010.

[I133] Bajpai RP. Coherent Nature of the Radiation Emitted ion Delayed Luminescence of Leaves. *J. Theor. Biol.*, 93:287–299, 1999.

[I134] Bajpai RP. Squeezed state description of spectral decompositions of a biophoton signal. *Phys Lett*, A 337:265–273, 2005.

[I135] Comorosan S. On a possible biological spectroscopy. *Bull Math Biol*, page 419, 1975.

[I136] Rackovsky S. On the nature of the protein folding code. *Proc Natl Acad Sci USA*, 90(2), 1993. Available at: `https://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=45720`. See also *Protein folding* at `https://en.wikipedia.org/wiki/Protein_folding`.

[I137] Qin F Sachs F. Gated, ion-selective channels observed with patch pipettes in the absence of membranes: novel properties of a gigaseal. *Biophys J*, pages 1101–1107, 1993.

[I138] Neher B Sakmann B. *Single-channel recording*. Plenum, London, 1983.

[I139] Tshitshinadze G Shaduri M. On the problem of application of Bioenergography in medicine. *Georgian Eng News*, 2, 1999.

[I140] Rau DC Sidorova NY. Differences between EcoRI Nonspecific and "Star" Sequence Complexes Revealed by Osmotic Stress. *Biophys J* . Available at: `https://www.biophysj.org/cgi/content/full/87/4/2564`, 87, 2004.

[I141] Levin M Somrat T. An automated training paradigm reveals long-term memory in planarians and its persistence through head regeneration. *The J Experimental Biology*, 216:3799–3810, 2013. Available at: `https://tinyurl.com/ntlxpep`.

[I142] Creighton TE. *Proteins: Structures and Molecular Properties*. Freeman, New York, 1993.

[I143] Karu TI. *The Sci of Low-Power Laser Therapy*. Gordon and Breach, Sci. Publ.. Available at: `https://www.laserhealthsystems.com/Dr.%20Tiina%20Karu%20Presentation.htm`, London, 1998.

[I144] Veljkovic V and Lalovic DI. Correlation between the carcinogenicity of organic substances and their spectral characteristics. *Experientia*, 34(10):1342–1343, 1978.

[I145] Vergara C Villar PS and Bacigalupo J. Energy sources that fuel metabolic processes in protruding finger-like organelles. *FEBS Journal*, 2020. Available at: `https://doi.org/10.1111/febs.15620`.

[I146] Merali Z. Water gave life on Earth a guiding hand. *New Scientist*, 2540:25, 2006.

[I147] Pollack GH Zheng J-M. Long-range forces extending from polymer-gel surfaces. *Phys Rev E*, 68:031408–, 2003. Available at: `https://tinyurl.com/ntkfhlc`.

Neuroscience and Consciousness

[J1] God helmet. Available at: `https://en.wikipedia.org/wiki/God_helmet`.

[J2] Out-of-body experience. Available at: `https://en.wikipedia.org/wiki/Out-of-body_experience`.

[J3] Action potential. Available at: `https://en.wikipedia.org/wiki/Action_potential`.

[J4] Bipolar Disorder. Available at: `https://www.nimh.nih.gov/publicat/bipolar.cfm#readNow`.

[J5] Color vision. Available at: `https://en.wikipedia.org/wiki/Color_vision`.

[J6] Discovery of quantum vibrations in microtubules inside brain neurons corroborates controversial 20-year old theory of consciousness? Available at: `https://cutt.ly/CaYbCzY`.

[J7] God and the Brain - The Persinger 'God Helmet', The Brain , and visions of God. Available at: `https://vimeo.com/22669312`.

[J8] Microtubules. Available at: `https://en.wikipedia.org/wiki/Microtubules`.

[J9] Near death experiences. Available at: `https://en.wikipedia.org/wiki/Near_death_experiences`.

[J10] Neurotheology. Available at: `https://en.wikipedia.org/wiki/Neurotheology`.

[J11] Pflanzenwachstum durch Elektrofeld. Available at: `https://www.s-line.de/homepages/keppler/elektrofeld.htm`. Instructions for the experiment yielding Ciba Geigy effect.

[J12] Photoreceptor cell. Available at: `https://en.wikipedia.org/wiki/Photoreceptor_cell`.

[J13] Physicists challenge notion of electric nerve impulses; say sound more likely. Available at: `https://tinyurl.com/2r2wpw`.

[J14] Qigong and Energy Medicine Database. Available at: `https://www.qigonginstitute.org/html/database.php`.

[J15] Retinal Transduction: Hyperpolarization of Primary Photoreceptors by Ligh. Available at: `https://www.acbrown.com/neuro/Lectures/NrVisn/NrVisnRtnlHprp.htm`.

[J16] Soliton model. Available at: `https://en.wikipedia.org/wiki/Soliton_model`.

[J17] Synaptic plasticity. Available at: `https://en.wikipedia.org/wiki/Synaptic_plasticity`.

[J18] Acousto-conformational transitions in cytoskeletal microtubules: implications for intracellular information processing. *Nanobiol*, 1:457–468, 1992.

[J19] Bandyopadhyay A. Experimental Studies on a Single Microtubule (Google Workshop on Quantum Biology), 2011. Available at: `https://www.youtube.com/watch?v=VQngptkPYE8`.

[J20] Revonsuo A. Is synchronization the direct neural correlate of visual consciousness?, 1998. Available at: `https://www.phil.vt.edu/ASSC/engel/revonsuo1.html`.

[J21] Botkin AL. The Induction of After-Dearth Communications Utilizing Eye-Movement Desensitization and Reprocessing: A New Discovery. *J Near-Death Studies*, (3):181, 2000.

[J22] Libet B. Readiness potentials preceding unrestricted spontaneous and preplanned voluntary acts, 1982. Available at: `https://tinyurl.com/jqp1`. See also the article *Libet's Research on Timing of Conscious Intention to Act: A Commentary* of Stanley Klein at `https://tinyurl.com/jqp1`.

[J23] Dias BB and Ressler KJ. Parental olfactory experience influences behavior and neural structure in subsequent generations. *Nature. Neuroscience*, 17:89–96, 2014.

[J24] Selden G Becker RO. *The Body Electric: Electromagnetism and the Foundation of Life.* William Morrow & Company, Inc., New York, 1990.

[J25] Antal I Bokkon I, Dai J. Picture representation during REM dreams: a redox molecular hypothesis. *Biosystems*, 100(2):79–86, 2010.

[J26] Mahagita C. Roles of meditation on alleviation of oxidative stress and improvement of antioxidant system. *J Med Assoc Thai*, 93 Suppl 6:S242–54, 2010.

[J27] Smith C. Learning From Water , A Possible Quantum Computing Medium. In *CASYS'2001, 5th international conference on Computing Anticipating Systems held in Liege, Belgium, August 13-18. Abstract book.* CHAOS, 2001.

[J28] Blackman CF. *Effect of Electrical and Magnetic Fields on the Nervous System*, pages 331–355. Plenum, New York, 1994.

[J29] Kerskens CM and Perez DL. Experimental indications of non-classical brain functions. *Journal of Physics Communications*, 6(10), 2022. Available at: `https://cutt.ly/0NtnEKz`. .

[J30] Yarrow D. Spin the tale of the dragon, 1990. Available at: `https://www.ratical.org/reatvlle/RofD2.html`.

[J31] Persinger MA Dotta BT, Saroka KS. Increased photon emission from the head while imagining light in the dark is correlated with changes in electroencephalographic power: support for B kkon's biophoton hypothesis. *Neurosci Lett*, 513(2):151–154, 2012.

[J32] Nanopoulos DV. Theory of Brain function, Quantum Mechanics, and Superstrings, 1995. Available at: `https://arxiv.org/abs/hep-ph/9505374`.

[J33] Walker EH. Quantum Mechanical Tunnelling in Synaptic and Ephaptic Transmission. *Int J Quant Chem*, 11, 1977.

[J34] Abdelmeik H et al. Impact of evolution on the electrical properties of sciatic nerves: superconductivity-like. *J Physical & Chemical News*, 2003.

[J35] Blackman CF et al. Effects of ELF fields on calcium-ion efflux from brain tissue, in vitro. *Radiat Res*, 92:510–520, 1982.

[J36] Blackman CF et al. A role for the magnetic field in the radiation-induced efflux of calcium ions from brain tissue, in vitro. *Bioelectromagn*, 6:327–337, 1985.

[J37] Bokkon I et al. Estimation of the number of biophotons involved in the visual perception of a single-object image: biophoton intensity can be considerably higher inside cells than outside. *J Photochem Photobiol B*, 2010.

[J38] Bokkon I et al. Visible light induced ocular delayed bioluminescence as a possible origin of negative afterimage. *J Photochem Photobiol B*, 103(2):192–119, 2011.

[J39] Bullock TH et al. Temporal fluctuations in coherence of brain waves, 1995. Available at: `https://tinyurl.com/nuv53uf`.

[J40] Cacciola A et al. Coalescent embedding in the hyperbolic space unsupervisedly discloses the hidden geometry of the brain, 2017. Available at:`https://arxiv.org/pdf/1705.04192.pdf`.

[J41] Chen W et al. Temperature and Biophoton Changes of the Middle Finger during Qigong and Light Imagery Tasks. *J Intl Soc Life Info Sci*, 2002.

[J42] Cheron G et al. Inactivation of Calcium-Binding Pr ein Genes Induces 160 Hz Oscillations in the Cerebellar Cortex of Alert Mice. *J Neurosci*, 2004:434–441, 2004.Available at: `https://www.jneurosci.org/cgi/content/full/24/2/434`.

[J43] Csibra G et al. Gamma oscillations and object processing in the infant brain. *Science*, 290:1582–1585, 2000.

[J44] Dubey J et al. Neurodegeneration and microtubule dynamics: death by a thousand cuts. *Front Cell Neurosci.*, 9: 343, 2015. Available at: `https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4563776/.` .

[J45] Engel AK et al. Temporal Binding, Binocular Rivalry, and Consciousness, 2000Available at: `https://www.phil.vt.edu/ASSC/engel/engel.html`.

[J46] Fingelkurts A et al. Consciousness as a phenomenon in the operational architectonics of brain organization: Critality and self-organization considerations. *Chaos, Solitons & Fractals*, 2013. Available at: `https://dx.doi.org/10.1016/locate/j.chaos.2013.02.007`.

[J47] Hameroff S et al. Conduction pathways in microtubules, biological quantum computation, and consciousness. *Biosystems*, 64(1-3):149–168, 2002. Available at: `https://www.quantumconsciousness.org/biosystemselsevier.htm`.

[J48] Haraguchi S et al. Biophoton Change by Mental Concentration. *J Intl Soc Life Info Sci*, 2001.

[J49] Hibbs AD et al. *Appl. Phys Lett*, 77(1995):66, 1995.

[J50] Kikkawa M et al. Direct visualization of the microtubule lattice seam both in vitro and in vivo. *JCB*, 127(6), 1994. Available at: `https://jcb.rupress.org/content/127/6/1965.abstract`.

[J51] Kobayashi M et al. In vivo imaging of spontaneousultraweak photon emission from a rat s brain correlated with cerebral energy metabolism and oxidative stress. *Neurosci Res*, 34:103–113, 1999.

[J52] Libet B et al. Subjective referral of the timing for a conscious sensory experience. *Brain*, 102, 1979.

[J53] Lin S et al. Comparison of bioenergy and physiological markers in qigong and acupuncture research. *National meeting of the Soc for Acupuncture Research*, 2004.

[J54] Lindenberger U et al. Brains swinging in concert: cortical phase synchronization while playing guitar. *BMC Neurosci*, 10:22, 2009. Available at: `https://tinyurl.com/oxyptn3`.

[J55] Lodato MA et al. Somatic mutation in single human neurons tracks developmental and transcriptional history. *Science*, 350(6256):94–98, 2015. Available at: `https://www.sciencemag.org/content/350/6256/94`.

[J56] Mandelkow E-M et al. On the Surface Lattice of Microtubules : Helix Starts, Protofilament Number, Seam, and Handedness, 1985.Available at: `https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2114131/pdf/jc10231067.pdf`.

[J57] Nakamura H et al. Biophoton and Temperature Changes of Human Hand during Qigong. *J Intl Soc Life Info Sci*, 2000.

[J58] Persinger M et al. Congruence of Energies for Cerebral Photon Emissions, Quantitative EEG Activities and 5 nT Changes in the Proximal Geomagnetic Field Support Spin-based Hypothesis of Consciousness. *J Consc Expl & Res*, 2013. Available at: `https://jcer.com/index.php/jcj/article/view/277`.

[J59] Persinger M et al. Demonstration of Entanglement of Pure Photon Emissions at Two Locations That Share Specific Configurations of Magnetic Fields: Implications for Translocation of Consciousness. *J Consc Expl & Res*, 2013. Available at: `https://jcer.com/index.php/jcj/article/view/278`.

[J60] Persinger M et al. Experimental Demonstration of Potential Entanglement of Brain Activity Over 300 Km for Pairs of Subjects Sharing the Same Circular Rotating, Angular Accelerating Magnetic Fields: Verification by s_LORETA, QEEG Measurements. *J Consc Expl & Res*, 2013. Available at: `https://jcer.com/index.php/jcj/article/view/279`.

[J61] Rahnama M et al. Emission of Biophotons and Neural Activity of the Brain , 2010. Available at: `https://www.scribd.com/doc/45664376/Bio-Photons`.

[J62] Redingaugh MJ et al. Thalamus Modulates Consciousness via Layer-Specific Control of Cortex. *Neuron*, 2020. Available at:`https://doi.org/10.1016/j.neuron.2020.01.005`.

[J63] Reimers JR et al. Penrose Hameroff orchestrated objective-reduction proposal for human consciousness is not biologically feasible. *Phys Rev E*, 80:021912 021916, 2009.

[J64] Reimers JR et al. Weak, strong, and coherent regimes of Fröhlich condensation and their applications to terahertz medicine and quantum consciousness. *Proc Natl Acad Sci*, 106:4219–4224, 2009.

[J65] Sahu S et al. Atomic water channel controlling remarkable properties of a single brain microtubule: correlating single protein to its supramolecular assembly. *Biosens Bioelectron*, 47:141–148, 201. Avalable at: https://www.sciencedirect.com/science/article/pii/S0956566313001590.

[J66] Sahu S et al. Multi-level memory-switching properties of a single brain microtubule . *Appl Phys Lett*, 102(123701), 2013. Available at: `https://dx.doi.org/10.1063/1.4793995`.

[J67] Sarovar M et al. Quantum entanglement in photosynthetic light harvesting complexes, 2010. Available at: `https://arxiv.org/pdf/0905.3787v2.pdf`.

[J68] Stroganova TA et al. EEG alpha rhythm in infants. *Clin Neurophysiol J*, 110(6):997–1012, 1999.

[J69] Tyszka JM et al. Intact Bilateral Resting-State Networks in the Absence of the Corpus Callosum. *The Journal of Neuroscience*, 2011. Available at:`https://tinyurl.com/3gjhtgb`.

[J70] Usui N et al. Very high frequency oscillations (over 1000 Hz) in human epilepsy. *Clin Neurophysiol*, 121:1825–1831, 2010.

[J71] Wang CH et al. Spontaneous and visible light-induced ultraweak photon emission from rat eyes. *Brain Res*, 1639:1–9, 2011.

[J72] Wijk Van R et al. Ultra-weak Photon Emission and EEG Alpha Rhythm. *NeuroQuantology*, 16:452–463, 2008.

[J73] Shapiro F. *Eye moment densensitization and reprocessing: Principles, processes and procedures.* Guilford, New York, 1995.

[J74] Rees G. Neuroimaging of visual awareness in patients and normal subjects. *Current Opinion In Neurobiology*, 11(2), 2001.

[J75] Bandyopadhyay A Ghosh G, Sahu S. Evidence of massive global synchronization and the consciousness: Comment on "Consciousness in the universe: A review of the 'Orch OR' theory" by Hameroff and Penrose. *Phys Life Rev*, 11:83–84, 2014.

[J76] Zipf GK. *Psycho-Biology of Languages.* MIT Press, 1965. Available at: `https://linkage.rockefeller.edu/wli/zipf/`. For references to Zipf's law see `https://linkage.rockefeller.edu/wli/zipf/`.

[J77] Hameroff S Graddock T, Tuszynksi A. Cytoskeletal Signaling: Is Memory Encoded in Microtubule Lattices by CaMKII Phosphorylation? *PLoS Comput Biol*, 8(3), 2012. Available at: `https://www.ploscompbiol.org/article/info:doi/10.1371/journal.pcbi.1002421`.

[J78] Gericke GS. Reactive oxygen species and related haem pathway components as possible epigenetic modifiers in neurobehavioural pathology. *Med Hypotheses*, 66(1):92–99, 2006.

[J79] Hameroff S Gupta S. The Possibility of MAPs as Quantum Logic Gates in Neuron al Microtubules, 2013.Available at: `https://sbs.arizona.edu/project/consciousness/report_poster_detail.php?abs=1435`.

[J80] Fröehlich H. Bose condensation of strongly excited longitudinal electric modes. *Phys Lett A*, 26:402–403, 1968.

[J81] Penrose R Hameroff S. Reply to criticism of the Orch OR qubit Orchestrated objective reduction is scientifically justified. *ScienceDirect*, 2013. Available at: `https://www.sciencedirect.com`.

[J82] Penrose R Hameroff SR. *Orchestrated reduction of quantum coherence in brain microtubules: A model for consciousness*, pages 507–540. MIT Press, Cambridge, 1996. Eds. S. R. Hameroff, A. Kaszniak and A.C. Scott.

[J83] Jackson AD Heimburg T. On soliton propagation in biomembranes and nerves. *PNAS*, 102(28):9790–9795, 2005.

[J84] Jackson AD Heimburg T. On the action potential as a propagating density pulse and the role of anesthetics. Available at: `https://arxiv.org/abs/physics/0610117`, 2005.

[J85] Wu M Hu H. Action Potential Modulation of Neural Spin Networks Suggests Possible Role of Spin. *NeuroQuantology*, 4:309–317, 2004. Available at: `https://cogprints.org/3458/1/SpinRole.pdf`.

[J86] Bokkon I. Phosphene phenomenon: a new concept. *Biosystems*, 92(2):168–174, 2008.

[J87] Bokkon I. Visual perception and imagery: a new molecular hypothesis. *Biosystems*, 96(2):178–184, 2009.

[J88] Bullier J. Feedback Connections and Conscious Vision. *Cell*, 2001.Available at: `https://www.trends.com`.

[J89] Hawkins J. *On Intelligence.* St. Martin's Griffin, New York, 2004.

[J90] Jaynes J. *The origin of consciousness in the breakdown of the bicameral mind.* Princeton University Press, 1982.

[J91] Pickering J. Active information in Physics. Available at: `https://tinyurl.com/qhx3suy`.

[J92] Spottiswoode J. Geomagnetic fluctuations and free response anomalous cognition: a new understanding. *J Parapsychol*, 2002. Available at: `https://www.jsasoc.com/docs/JP-GMF.pdf`.

[J93] Miller JP. Brain Waves Deciphered. *Nature*, 384:6605, 1996. Article about the work of Wehr and Laurent.

[J94] Pathel JP and Frey BN. Disruption in the Blood-Brain Barrier: The Missing Link between Brain and Body Inflammation in Bipolar Disorder? *Neural Plasticity*, 2015, Article ID 708306, 2015.`https://www.hindawi.com/journals/np/2015/708306/`.

[J95] Graesboll K. Function of Nerves-Action of Anesthetics. *Gamma*, 143, 2006. Available at: `https://www.gamma.nbi.dk`.

[J96] Pribram KH. The Neurophysiology of Remembering. *Sci Am*, 1969.

[J97] Pribram KH. *Brain and Perception; Holonomy and Structure in Figural Processing.* Lawrence Eribaum Associates, 1991.

[J98] Fantappie L. *Teoria Unitaria del Mondo Fisico e Biologico.* Di Renzo Editore, Roma, 1942.

[J99] Jaffe LF. Calcium Waves, 2001. Available at: `https://waves.mbl.edu/calcium.waves.html`.

[J100] Rees G Lumer ED. Covariation of activity in visual and prefrontal cortex associated with subjective visual perception. *Neurobiol*, 96(4), 1999.

[J101] Bischof M. Biophotons-The light in our cells. *J Optometric Phototherapy*, pages 1–5, 2005.

[J102] Germine M. Scientific Validation of Planetary Consciousness. *J Non-Locality and Remote Mental Interactions*, 1(3), 2002. Available at: `https://www.emergentmind.org/germineI3.htm`.

[J103] Persinger M. The tectonic strain theory as an explanation for UFO phenomena, 1999. Available at: `https://www.laurentian.ca/www/neurosci/tectonicedit.htm`.

[J104] Perus M. Neural correlates of vision and attention, 2001. Available at: `https://ai.fri.uni-lj.si/xaigor/articles/perus2.doc`.

[J105] Amstrong K Moore T. Selective gating of visual signals by micro-stimulation of frontal cortex. *Nature*, 421, 2003.

[J106] Recce ML O'Keefe J. Phase relationship between hippocampal place units and the EEG theta rhythm. *Hippocampus.* Available at: `https://www3.interscience.wiley.com/cgi-bin/abstract/109711451/ABSTRACT`, (3):317–330.

[J107] Pietch P. Shuffle Brain: the The Quest for Hologramic Mind, 1972. Available at: `https://www.indiana.edu/~pietsch/shufflebrain-book00.html`.

[J108] Walsh V Pascual-Leone A. Fast back projections from the motion to the primary visual area necessary for visual awareness. *Science*, 292, 2001.

[J109] Lavallee F C Persinger MA. Theoretical and Experimental Evidence of Macroscopic Entanglement between Human Brain Activity and Photon Emissions: Implications for Quantum Consciousness and Future Applications. *J Consc Expl & Res*, 1(7):785–807, 2010.

[J110] Eeg-Olofsson O Petersen I. The development of the electroencephalogram in normal children from the age of 1 through 15 years. *Neuropaediatrie*, 2, 1971.

[J111] Nunez PL. Toward a Quantitative Description of Large Scale Neocortical Dynamic Function and EEG. *Behav & Brain Sci*, 23, 2000.

[J112] Merrick R. *Interference: A Grand Scientific Musical Theory.* 2009. Available at: `https://interferencetheory.com/files/Interference.pdf`.

[J113] Becker RO. *Cross Currents.* Penguin Putnam Inc., New York, 1990.

[J114] Persinger Koren S Ruttan LA, MA. Enhancement of Temporal Lobe-Related Experiences During Brief Exposures to MilliGauss Intensity Extremely Low Frequency Magnetic Fields. *J Bioelectricity*, 9(1):33–54, 1998.

[J115] Klein S. Libet's Research on Timing of Conscious Intention to Act: A Commentary. *Consc & Cogn*, 11, 2002. Available at: `https://tinyurl.com/jqp1`.

[J116] Tippit S. Mind continues after brain dies, scientist says, 2001. An article of Guardian about the work of University of Southampton research team about NDE. Available at: `https://tinyurl.com/o5gnlnp`.

[J117] Chen KW Sidorov L. Biophysical Mechanisms of Genetic Regulation: Is There a Link to Mind-Body Healing? *DNA Decipher J*, 2(2):177–205, 2012.

[J118] Dai J Sun Y, Wang C. Biophotons as neural communication signals demonstrated by in situ biophoton autography. *Photochem Photobiol Sci*, 9:315–322, 2010.

[J119] Dibble WEJr Tiller WA. New experimental data revealing an unexpected dimension to materials science and engineering. *Mat Res Innovat*, 5:21–34, 2001.

[J120] Dibble WEJr Tiller WA. Anomalous Temperature Oscillation Behavior Near a Source in a "Conditioned" Space: part I, The Spatial Variation, 2002. Available at: `https://tillerfoundation.com/newpapers.htm`.

[J121] Picton TW. What is encephalogram?, 2001. Available at: `https://www.rotman-baycrest.on.ca/content/science/eegsub.html`.

[J122] Frisch von K. *The Dance Language and Orientation of Bees*. Harward University Press, 1967.

[J123] Tiller WA. Towards a Quantitative Science and Technology that Includes Human Consciousness. *Vision-In-Action*, 4, 2003. Available at: `https://www.via-visioninaction.org`.

[J124] Wijk Van R Wijk Van EP, Ackerman J. Effect of meditation on ultraweak photon emission from hands and forehead. *Res complementary & natural classical medicine*, 12(2):107–112, 2005.

[J125] Yamaguchi Y. Neural dynamics in Hippocampal Memory Formation via Theta Rhythm, 2003. Available at: `https://www.brain.riken.jp/bsi-news/bsinews22/no22/speciale.html`.

[J126] Yamaguchi Y. Laboratory for dynamics of emergent intelligence, 2003. Available at: `https://www.brain.riken.jp/reports/annual_reports/2003/2003-doc/0243.pdf`.

Books related to TGD

[K1] Pitkänen M Gariaev P. Model for the Findings about Hologram Generating Properties of DNA. In *Genes and Memes: Part I.* `https://tgdtheory.fi/tgdhtml/Bgenememe1.html`. Available at: `https://tgdtheory.fi/pdfpool/dnahologram.pdf`, 2023.

[K2] Pitkänen M. Hydrodynamics and CP_2 Geometry. In *TGD and Condensed Matter.* `https://tgdtheory.fi/tgdhtml/BTGDcondmat.html`.

[K3] Pitkänen M. *Topological Geometrodynamics*. 1983. Thesis in Helsinki University 1983.

[K4] Pitkänen M. *Life and Consciousness: TGD based vision*. Lambert. Available at: `https://tinyurl.com/zn98vka.`, 2014.

[K5] Pitkänen M. DNA as Topological Quantum Computer. In *Quantum - and Classical Computation in TGD Universe.* `https://tgdtheory.fi/tgdhtml/Btgdcomp.html`. Available at: `https://tgdtheory.fi/pdfpool/dnatqc.pdf`, 2015.

[K6] Pitkänen M. Topological Quantum Computation in TGD Universe. In *Quantum - and Classical Computation in TGD Universe.* `https://tgdtheory.fi/tgdhtml/Btgdcomp.html`. Available at: `https://tgdtheory.fi/pdfpool/tqc.pdf`, 2015.

[K7]   Pitkänen M. *Topological Geometrodynamics: Revised Edition*. Bentham.Available at: `https://tinyurl.com/h26hqul.`, 2016.

[K8]   Pitkänen M. Philosophy of Adelic Physics. In *TGD as a Generalized Number Theory: Part I.* `https://tgdtheory.fi/tgdhtml/Btgdnumber1.html`. Available at: `https://tgdtheory.fi/pdfpool/adelephysics.pdf`, 2017.

[K9]   Pitkänen M. Some comments related to Zero Energy Ontology (ZEO). In *TGD and Nuclear Physics.* `https://tgdtheory.fi/tgdhtml/Bnucl.html`. Available at: `https://tgdtheory.fi/pdfpool/zeoquestions.pdf`, 2019.

[K10] Pitkänen M. A Model for Protein Folding and Bio-catalysis. In *TGD and Quantum Biology: Part I.* `https://tgdtheory.fi/tgdhtml/Bqbio1.html`. Available at: `https://tgdtheory.fi/pdfpool/foldcat.pdf`, 2023.

[K11] Pitkänen M. A Possible Explanation of Shnoll Effect. In *TGD and Fringe Physics.* `https://tgdtheory.fi/tgdhtml/Bfreenergies.html`. Available at: `https://tgdtheory.fi/pdfpool/ShnollTGD.pdf`, 2023.

[K12] Pitkänen M. About Concrete Realization of Remote Metabolism. In *TGD and Fringe Physics.* `https://tgdtheory.fi/tgdhtml/Bfreenergies.html`. Available at: `https://tgdtheory.fi/pdfpool/remotetesla.pdf`, 2023.

[K13] Pitkänen M. About Nature of Time. In *TGD Inspired Theory of Consciousness: Part I.* `https://tgdtheory.fi/tgdhtml/Btgdconsc1.html`. Available at: `https://tgdtheory.fi/pdfpool/timenature.pdf`, 2023.

[K14] Pitkänen M. About Preferred Extremals of Kähler Action. In *Physics in Many-Sheeted Space-Time: Part I.* `https://tgdtheory.fi/tgdhtml/Btgdclass1.html`. Available at: `https://tgdtheory.fi/pdfpool/prext.pdf`, 2023.

[K15] Pitkänen M. About Strange Effects Related to Rotating Magnetic Systems . In *TGD and Fringe Physics.* `https://tgdtheory.fi/tgdhtml/Bfreenergies.html`. Available at: `https://tgdtheory.fi/pdfpool/Faraday.pdf`, 2023.

[K16] Pitkänen M.   About TGD counterparts of twistor amplitudes.   In *Quantum TGD: Part III.* `https://tgdtheory.fi/tgdhtml/Btgdquantum3.html`. Available at: `https://tgdtheory.fi/pdfpool/twisttgd.pdf`, 2023.

[K17] Pitkänen M. About the New Physics Behind Qualia. In *Bio-Systems as Self-Organizing Quantum Systems.* `https://tgdtheory.fi/tgdhtml/BbioSO.html`. Available at: `https://tgdtheory.fi/pdfpool/newphys.pdf`, 2023.

[K18] Pitkänen M. About the Nottale's formula for h_{gr} and the possibility that Planck length l_P and CP_2 length R are related. In *Dark Matter and TGD:* `https://tgdtheory.fi/tgdhtml/Bdark.html`. Available at: `https://tgdtheory.fi/pdfpool/vzerovariableG.pdf`, 2023.

[K19] Pitkänen M.   About twistor lift of TGD?   In *Quantum TGD: Part III.* `https://tgdtheory.fi/tgdhtml/Btgdquantum3.html`. Available at: `https://tgdtheory.fi/pdfpool/hgrtwistor.pdf`, 2023.

[K20] Pitkänen M. Are dark photons behind biophotons? In *TGD and Quantum Biology: Part I.* `https://tgdtheory.fi/tgdhtml/Bqbio1.html`. Available at: `https://tgdtheory.fi/pdfpool/biophotonslian.pdf`, 2023.

[K21] Pitkänen M. Basic Properties of CP_2 and Elementary Facts about p-Adic Numbers. In *Quantum TGD: Part I.* `https://tgdtheory.fi/tgdhtml/Btgdquantum1.html`. Available at: `https://www.tgdtheory.fi/public_html/pdfpool/append.pdf`, 2023.

[K22] Pitkänen M. *Bio-Systems as Conscious Holograms*. Online book. Available at: `https://www.tgdtheory.fi/tgdhtml/holography.html.`, 2023.

[K23] Pitkänen M. Bio-Systems as Conscious Holograms. In *TGD Universe as a Conscious Hologram. https: // tgdtheory. fi/ tgdhtml/ Bholography. html*. Available at: `https: //tgdtheory.fi/pdfpool/hologram.pdf`, 2023.

[K24] Pitkänen M. *Bio-Systems as Self-Organizing Quantum Systems*. Online book. Available at: `https://www.tgdtheory.fi/tgdhtml/bioselforg.html.`, 2023.

[K25] Pitkänen M. Bio-Systems as Super-Conductors: Part I. In *Bio-Systems as Self-Organizing Quantum Systems. https: // tgdtheory. fi/ tgdhtml/ BbioSO. html*. Available at: `https: //tgdtheory.fi/pdfpool/superc1.pdf`, 2023.

[K26] Pitkänen M. Bio-Systems as Super-Conductors: part II. In *Bio-Systems as Self-Organizing Quantum Systems. https: // tgdtheory. fi/ tgdhtml/ BbioSO. html*. Available at: `https: //tgdtheory.fi/pdfpool/superc2.pdf`, 2023.

[K27] Pitkänen M. Biological Realization of Self Hierarchy. In *Bio-Systems as Self-Organizing Quantum Systems. https: // tgdtheory. fi/ tgdhtml/ BbioSO. html*. Available at: `https: //tgdtheory.fi/pdfpool/bioselfc.pdf`, 2023.

[K28] Pitkänen M. Classical TGD. In *Topological Geometrodynamics: Overview: Part I:https: // tgdtheory. fi/ tgdhtml/ Btgdview1. html*. Available at: `https://tgdtheory.fi/ pdfpool/tgdclass.pdf`, 2023.

[K29] Pitkänen M. Cold Fusion Again. In *TGD and Nuclear Physics. https: // tgdtheory. fi/ tgdhtml/ Bnucl. html*. Available at: `https://tgdtheory.fi/pdfpool/coldfusionagain. pdf`, 2023.

[K30] Pitkänen M. Comments on the recent experiments by the group of Michael Persinger. In *TGD and EEG: Part I. https: // tgdtheory. fi/ tgdhtml/ Btgdeeg1. html*. Available at: `https://tgdtheory.fi/pdfpool/persconsc.pdf`, 2023.

[K31] Pitkänen M. Comparing Berry phase model of super-conductivity with TGD based model. In *TGD and Condensed Matter. https: // tgdtheory. fi/ tgdhtml/ BTGDcondmat. html*. Available at: `https://tgdtheory.fi/pdfpool/SCBerryTGD.pdf`, 2023.

[K32] Pitkänen M. Comparison of TGD inspired theory of consciousness with some other theories of consciousness. In *TGD Inspired Theory of Consciousness: Part II. https: // tgdtheory. fi/ tgdhtml/ Btgdconsc2. html*. Available at: `https://tgdtheory.fi/ pdfpool/consccomparison.pdf`, 2023.

[K33] Pitkänen M. Construction of elementary particle vacuum functionals. In *p-Adic Physics. https: // tgdtheory. fi/ tgdhtml/ Bpadphys. html*. Available at: `https://tgdtheory. fi/pdfpool/elvafu.pdf`, 2023.

[K34] Pitkänen M. Construction of Quantum Theory: M-matrix. In *Quantum TGD: Part I. https: // tgdtheory. fi/ tgdhtml/ Btgdquantum1. html*. Available at: `https:// tgdtheory.fi/pdfpool/towards.pdf`, 2023.

[K35] Pitkänen M. Construction of WCW Kähler Geometry from Symmetry Principles. In *Quantum Physics as Infinite-Dimensional Geometry. https: // tgdtheory. fi/ tgdhtml/ Btgdgeom. html*. Available at: `https://tgdtheory.fi/pdfpool/compl1.pdf`, 2023.

[K36] Pitkänen M. Could Genetic Code Be Understood Number Theoretically? In *Genes and Memes: Part I. https: // tgdtheory. fi/ tgdhtml/ genememe1. html*. Available at: `https://tgdtheory.fi/pdfpool/genenumber.pdf`, 2023.

[K37] Pitkänen M. Criticality and dark matter: part I. In *Dark Matter and TGD: https: // tgdtheory. fi/ tgdhtml/ Bdark. html*. Available at: `https://tgdtheory.fi/pdfpool/ qcritdark1.pdf`, 2023.

[K38] Pitkänen M. Criticality and dark matter: part II. In *Dark Matter and TGD: https: // tgdtheory. fi/ tgdhtml/ Bdark. html*. Available at: `https://tgdtheory.fi/pdfpool/ qcritdark2.pdf`, 2023.

[K39] Pitkänen M. Criticality and dark matter: part III. In *Dark Matter and TGD: https: // tgdtheory. fi/ tgdhtml/ Bdark. html* . Available at: https://tgdtheory.fi/pdfpool/ qcritdark3.pdf, 2023.

[K40] Pitkänen M. Criticality and dark matter: part IV. In *Dark Matter and TGD: https: // tgdtheory. fi/ tgdhtml/ Bdark. html* . Available at: https://tgdtheory.fi/pdfpool/ qcritdark4.pdf, 2023.

[K41] Pitkänen M. Crop Circles and Life at Parallel Space-Time Sheets. In *Magnetospheric Consciousness. https: // tgdtheory. fi/ tgdhtml/ Bmagnconsc. html* . Available at: https: //tgdtheory.fi/pdfpool/crop1.pdf, 2023.

[K42] Pitkänen M. Crop Circles and Life at Parallel Space-Time Sheets. In *Magnetospheric Consciousness. https: // tgdtheory. fi/ tgdhtml/ Bmagnconsc. html* . Available at: https: //tgdtheory.fi/pdfpool/crop2.pdf, 2023.

[K43] Pitkänen M. Dark Forces and Living Matter. In *Bio-Systems as Self-Organizing Quantum Systems. https: // tgdtheory. fi/ tgdhtml/ BbioSO. html* . Available at: https:// tgdtheory.fi/pdfpool/darkforces.pdf, 2023.

[K44] Pitkänen M. Dark Matter Hierarchy and Hierarchy of EEGs. In *TGD and EEG: Part I. https: // tgdtheory. fi/ tgdhtml/ Btgdeeg1. html* . Available at: https://tgdtheory. fi/pdfpool/eegdark.pdf, 2023.

[K45] Pitkänen M. Dark Nuclear Physics and Condensed Matter. In *TGD and Nuclear Physics. https: // tgdtheory. fi/ tgdhtml/ Bnucl. html* . Available at: https://tgdtheory.fi/ pdfpool/exonuclear.pdf, 2023.

[K46] Pitkänen M. Does TGD Predict a Spectrum of Planck Constants? In *Dark Matter and TGD: https: // tgdtheory. fi/ tgdhtml/ Bdark. html* . Available at: https://tgdtheory.fi/ pdfpool/Planck, 2023.

[K47] Pitkänen M. Evolution in Many-Sheeted Space-Time: Part I. In *Evolution in TGD Universe. https: // tgdtheory. fi/ tgdhtml/ Btgdevolution. html* . Available at: https: //tgdtheory.fi/pdfpool/prebio1.pdf, 2023.

[K48] Pitkänen M. Evolution in Many-Sheeted Space-Time: Part II. In *Evolution in TGD Universe. https: // tgdtheory. fi/ tgdhtml/ Btgdevolution. html* . Available at: https: //tgdtheory.fi/pdfpool/prebio2.pdf, 2023.

[K49] Pitkänen M. From Principles to Diagrams. In *Quantum TGD: Part III. https: // tgdtheory. fi/ tgdhtml/ Btgdquantum3. html* . Available at: https://tgdtheory.fi/ pdfpool/diagrams.pdf, 2023.

[K50] Pitkänen M. General Theory of Qualia. In *TGD Inspired Theory of Consciousness: Part I. https: // tgdtheory. fi/ tgdhtml/ Btgdconsc1. html* . Available at: https://tgdtheory. fi/pdfpool/qualia.pdf, 2023.

[K51] Pitkänen M. *Genes and Memes*. Online book. Available at: https://www.tgdtheory.fi/ tgdhtml/genememe.html., 2023.

[K52] Pitkänen M. Genes and Memes. In *Genes and Memes: Part I. https: // tgdtheory. fi/ tgdhtml/ Bgenememe1. html* . Available at: https://tgdtheory.fi/pdfpool/genememec. pdf, 2023.

[K53] Pitkänen M. Homeopathy in Many-Sheeted Space-Time. In *TGD Universe as a Conscious Hologram. https: // tgdtheory. fi/ tgdhtml/ Bholography. html* . Available at: https: //tgdtheory.fi/pdfpool/homeoc.pdf, 2023.

[K54] Pitkänen M. *Hyper-finite Factors and Dark Matter Hierarchy*. Online book. Available at: https://www.tgdtheory.fi/tgdhtml/neuplanck.html., 2023.

[K55] Pitkänen M. Identification of the WCW Kähler Function. In *Quantum Physics as Infinite-Dimensional Geometry.* *https: // tgdtheory. fi/ tgdhtml/ Btgdgeom. html* . Available at: https://tgdtheory.fi/pdfpool/kahler.pdf., 2023.

[K56] Pitkänen M. Knots and TGD. In *Quantum Physics as Infinite-Dimensional Geometry.* *https: // tgdtheory. fi/ tgdhtml/ Btgdgeom. html* . Available at: https://tgdtheory.fi/pdfpool/knotstgd.pdf, 2023.

[K57] Pitkänen M. Macroscopic Quantum Coherence and Quantum Metabolism as Different Sides of the Same Coin: Part I. In *TGD Universe as a Conscious Hologram.* *https: // tgdtheory. fi/ tgdhtml/ Bholography. html* . Available at: https://tgdtheory.fi/pdfpool/metab.pdf, 2023.

[K58] Pitkänen M. Macroscopic Quantum Coherence and Quantum Metabolism as Different Sides of the Same Coin: Part II. In *TGD Universe as a Conscious Hologram.* *https: // tgdtheory. fi/ tgdhtml/ Bholography. html* . Available at: https://tgdtheory.fi/pdfpool/molephoto.pdf, 2023.

[K59] Pitkänen M. Macroscopic Quantum Phenomena and CP_2 Geometry. In *TGD and Condensed Matter.* *https: // tgdtheory. fi/ tgdhtml/ BTGDcondmat. html* . Available at: https://tgdtheory.fi/pdfpool/super.pdf, 2023.

[K60] Pitkänen M. Magnetic Sensory Canvas Hypothesis. In *TGD and Quantum Biology: Part I.* *https: // tgdtheory. fi/ tgdhtml/ Bqbio1. html* . Available at: https://tgdtheory.fi/pdfpool/mec.pdf, 2023.

[K61] Pitkänen M. *Magnetospheric Consciousness.* Online book. Available at: https://www.tgdtheory.fi/tgdhtml/magnconsc.html., 2023.

[K62] Pitkänen M. Magnetospheric Sensory Representations. In *Magnetospheric Consciousness.* *https: // tgdtheory. fi/ tgdhtml/ Bmagnconsc. html* . Available at: https://tgdtheory.fi/pdfpool/srepres.pdf, 2023.

[K63] Pitkänen M. Many-Sheeted DNA. In *Genes and Memes: Part I.* *https: // tgdtheory. fi/ tgdhtml/ Bgenememe1. html* . Available at: https://tgdtheory.fi/pdfpool/genecodec.pdf, 2023.

[K64] Pitkänen M. Massless states and particle massivation. In *p-Adic Physics.* *https: // tgdtheory. fi/ tgdhtml/ Bpadphys. html* . Available at: https://tgdtheory.fi/pdfpool/mless.pdf, 2023.

[K65] Pitkänen M. *Mathematical Aspects of Consciousness Theory.* Online book. Available at: https://www.tgdtheory.fi/tgdhtml/mathconsc.html, 2023.

[K66] Pitkänen M. Matter, Mind, Quantum. In *TGD Inspired Theory of Consciousness: Part I.* *https: // tgdtheory. fi/ tgdhtml/ Btgdconsc1. html* . Available at: https://tgdtheory.fi/pdfpool/conscic.pdf, 2023.

[K67] Pitkänen M. Meditation, Mind-Body Medicine and Placebo: TGD point of view. In *TGD Inspired Theory of Consciousness: Part III.* *https: // tgdtheory. fi/ tgdhtml/ Btgdconsc3. html* . Available at: https://tgdtheory.fi/pdfpool/panel.pdf, 2023.

[K68] Pitkänen M. More about TGD Inspired Cosmology. In *Physics in Many-Sheeted Space-Time: Part II.* *https: // tgdtheory. fi/ tgdhtml/ Btgdclass2. html* . Available at: https://tgdtheory.fi/pdfpool/cosmomore.pdf, 2023.

[K69] Pitkänen M. More Precise TGD View about Quantum Biology and Prebiotic Evolution. In *Evolution in TGD Universe.* *https: // tgdtheory. fi/ tgdhtml/ Btgdevolution. html* . Available at: https://tgdtheory.fi/pdfpool/geesink.pdf, 2023.

[K70] Pitkänen M. Negentropy Maximization Principle. In *TGD Inspired Theory of Consciousness: Part I.* *https: // tgdtheory. fi/ tgdhtml/ Btgdconsc1. html* . Available at: https://tgdtheory.fi/pdfpool/nmpc.pdf, 2023.

[K71] Pitkänen M. New Physics Predicted by TGD: Part I. In *p-Adic Physics.* *https: // tgdtheory. fi/ tgdhtml/ Bpadphys. html*. Available at: `https://tgdtheory. fi/pdfpool/TGDnewphys1.pdf`, 2023.

[K72] Pitkänen M. New Physics Predicted by TGD: Part II. In *p-Adic Physics.* *https: // tgdtheory. fi/ tgdhtml/ Bpadphys. html*. Available at: `https://tgdtheory. fi/pdfpool/TGDnewphys2.pdf`, 2023.

[K73] Pitkänen M. Non-locality in quantum theory, in biology and neuroscience, and in remote mental interactions: TGD perspective. In *TGD Inspired Theory of Consciousness: Part III.* *https: // tgdtheory. fi/ tgdhtml/ Btgdconsc3. html*. Available at: `https://tgdtheory. fi/pdfpool/nonlocal.pdf`, 2023.

[K74] Pitkänen M. Nuclear String Hypothesis. In *TGD and Nuclear Physics.* *https: // tgdtheory. fi/ tgdhtml/ Bnucl. html*. Available at: `https://tgdtheory.fi/pdfpool/ nuclstring.pdf`, 2023.

[K75] Pitkänen M. Number theoretic vision, Hyper-finite Factors and S-matrix. In *Quantum TGD: Part I.* *https: // tgdtheory. fi/ tgdhtml/ Btgdquantum1. html*. Available at: `https:// tgdtheory.fi/pdfpool/UandM.pdf`, 2023.

[K76] Pitkänen M. *p-Adic length Scale Hypothesis.* Online book. Available at: `https://www. tgdtheory.fi/tgdhtml/padphys.html.`, 2023.

[K77] Pitkänen M. p-Adic Particle Massivation: Hadron Masses. In *p-Adic Physics.* *https: // tgdtheory. fi/ tgdhtml/ Bpadphys. html*. Available at: `https://tgdtheory. fi/pdfpool/mass3.pdf`, 2023.

[K78] Pitkänen M. Physics as a Generalized Number Theory. In *Topological Geometrodynamics: Overview: Part I.* *https: // tgdtheory. fi/ tgdhtml/ Btgdview1. html*. Available at: `https://tgdtheory.fi/pdfpool/tgdnumber.pdf`, 2023.

[K79] Pitkänen M. Quantum Antenna Hypothesis. In *Bio-Systems as Self-Organizing Quantum Systems.* *https: // tgdtheory. fi/ tgdhtml/ BbioSO. html*. Available at: `https:// tgdtheory.fi/pdfpool/tubuc.pdf`, 2023.

[K80] Pitkänen M. Quantum Arithmetics and the Relationship between Real and p-Adic Physics. In *TGD as a Generalized Number Theory: Part III.* *https: // tgdtheory. fi/ tgdhtml/ Btgdnumber3. html*. Available at: `https://tgdtheory.fi/pdfpool/qarithmetics.pdf`, 2023.

[K81] Pitkänen M. Quantum Astrophysics. In *Physics in Many-Sheeted Space-Time: Part II.* *https: // tgdtheory. fi/ tgdhtml/ Btgdclass2. html*. Available at: `https://tgdtheory. fi/pdfpool/qastro.pdf`, 2023.

[K82] Pitkänen M. Quantum Control and Coordination in Bio-Systems. In *Bio-Systems as Self-Organizing Quantum Systems.* *https: // tgdtheory. fi/ tgdhtml/ BbioSO. html*. Available at: `https://tgdtheory.fi/pdfpool/qcococII.pdf`, 2023.

[K83] Pitkänen M. Quantum gravity, dark matter, and prebiotic evolution. In *Evolution in TGD Universe.* *https: // tgdtheory. fi/ tgdhtml/ Btgdevolution. html*. Available at: `https://tgdtheory.fi/pdfpool/hgrprebio.pdf`, 2023.

[K84] Pitkänen M. Quantum Hall effect and Hierarchy of Planck Constants. In *TGD and Condensed Matter.* *https: // tgdtheory. fi/ tgdhtml/ BTGDcondmat. html*. Available at: `https://tgdtheory.fi/pdfpool/anyontgd.pdf`, 2023.

[K85] Pitkänen M. *Quantum Hardware of Living Matter.* Online book. Available at: `https: //www.tgdtheory.fi/tgdhtml/bioware.html.`, 2023.

[K86] Pitkänen M. Quantum Mind and Neuroscience. In *TGD and EEG: Part I.* *https: // tgdtheory. fi/ tgdhtml/ Btgdeeg1. html*. Available at: `https://tgdtheory. fi/pdfpool/lianPN.pdf`, 2023.

[K87] Pitkänen M. Quantum Mind in TGD Universe. In *TGD Inspired Theory of Consciousness: Part I.* *https://tgdtheory.fi/tgdhtml/Btgdconsc1.html*. Available at: https://tgdtheory.fi/pdfpool/lianPC.pdf, 2023.

[K88] Pitkänen M. Quantum Mind, Magnetic Body, and Biological Body. In *TGD and Quantum Biology: Part I.* *https://tgdtheory.fi/tgdhtml/Bqbio1.html*. Available at: https://tgdtheory.fi/pdfpool/lianPB.pdf, 2023.

[K89] Pitkänen M. Quantum Model for Bio-Superconductivity: I. In *TGD and Quantum Biology: Part I.* *https://tgdtheory.fi/tgdhtml/Bqbio1.html*. Available at: https://tgdtheory.fi/pdfpool/biosupercondI.pdf, 2023.

[K90] Pitkänen M. Quantum Model for Bio-Superconductivity: II. In *TGD and Quantum Biology: Part I.* *https://tgdtheory.fi/tgdhtml/Bqbio1.html*. Available at: https://tgdtheory.fi/pdfpool/biosupercondII.pdf, 2023.

[K91] Pitkänen M. Quantum Model for Hearing. In *TGD and EEG: Part II.* *https://tgdtheory.fi/tgdhtml/Btgdeeg2.html*. Available at: https://tgdtheory.fi/pdfpool/hearing.pdf, 2023.

[K92] Pitkänen M. Quantum Model for Nerve Pulse. In *TGD and EEG: Part I.* *https://tgdtheory.fi/tgdhtml/Btgdeeg1.html*. Available at: https://tgdtheory.fi/pdfpool/nervepulse.pdf, 2023.

[K93] Pitkänen M. Quantum Model for Paranormal Phenomena. In *TGD Inspired Theory of Consciousness: Part III.* *https://tgdtheory.fi/tgdhtml/Btgdconsc3.html*. Available at: https://tgdtheory.fi/pdfpool/parac.pdf, 2023.

[K94] Pitkänen M. Quantum Model for Sensory Representations. In *TGD Inspired Theory of Consciousness: Part I.* *https://tgdtheory.fi/tgdhtml/Btgdconsc1.html*. Available at: https://tgdtheory.fi/pdfpool/expc.pdf, 2023.

[K95] Pitkänen M. Quantum Model of EEG. In *TGD and EEG: Part I.* *https://tgdtheory.fi/tgdhtml/Btgdeeg1.html*. Available at: https://tgdtheory.fi/pdfpool/eegII.pdf, 2023.

[K96] Pitkänen M. Quantum Model of Memory. In *TGD Inspired Theory of Consciousness: Part I.* *https://tgdtheory.fi/tgdhtml/Btgdconsc1.html*. Available at: https://tgdtheory.fi/pdfpool/memoryc.pdf, 2023.

[K97] Pitkänen M. *Quantum TGD*. Online book. Available at: https://www.tgdtheory.fi/tgdhtml/tgdquantum.html., 2023.

[K98] Pitkänen M. Quantum Theory of Self-Organization. In *Bio-Systems as Self-Organizing Quantum Systems.* *https://tgdtheory.fi/tgdhtml/BbioSO.html*. Available at: https://tgdtheory.fi/pdfpool/selforgac.pdf, 2023.

[K99] Pitkänen M. Recent View about Kähler Geometry and Spin Structure of WCW. In *Quantum Physics as Infinite-Dimensional Geometry.* *https://tgdtheory.fi/tgdhtml/Btgdgeom.html*. Available at: https://tgdtheory.fi/pdfpool/wcwnew.pdf, 2023.

[K100] Pitkänen M. Riemann Hypothesis and Physics. In *TGD as a Generalized Number Theory: Part III.* *https://tgdtheory.fi/tgdhtml/Btgdnumber3.html*. Available at: https://tgdtheory.fi/pdfpool/riema.pdf, 2023.

[K101] Pitkänen M. Self and Binding: Part I. In *TGD Inspired Theory of Consciousness: Part I.* *https://tgdtheory.fi/tgdhtml/Btgdconsc1.html*. Available at: https://tgdtheory.fi/pdfpool/selfbindc.pdf, 2023.

[K102] Pitkänen M. Some questions related to the twistor lift of TGD. In *Quantum TGD: Part III.* *https://tgdtheory.fi/tgdhtml/Btgdquantum3.html*. Available at: https://tgdtheory.fi/pdfpool/twistquestions.pdf, 2023.

[K103] Pitkänen M. Symmetries and Geometry of the "World of Classical Worlds". In *Quantum Physics as Infinite-Dimensional Geometry*. *https: // tgdtheory. fi/ tgdhtml/ Btgdgeom. html*. Available at: https://tgdtheory.fi/pdfpool/wcwsymm.pdf, 2023.

[K104] Pitkänen M. TGD and Astrophysics. In *Physics in Many-Sheeted Space-Time: Part II*. *https: // tgdtheory. fi/ tgdhtml/ Btgdclass2. html*. Available at: https://tgdtheory.fi/pdfpool/astro.pdf, 2023.

[K105] Pitkänen M. TGD and condensed matter physics. In *TGD and Condensed Matter*. *https: // tgdtheory. fi/ tgdhtml/ BTGDcondmat. html*. Available at: https://tgdtheory.fi/pdfpool/TGDcondmatshort.pdf, 2023.

[K106] Pitkänen M. *TGD and EEG*. Online book. Available at: https://www.tgdtheory.fi/tgdhtml/tgdeeg.html, 2023.

[K107] Pitkänen M. *TGD and Fringe Physics*. Online book. Available at: https://www.tgdtheory.fi/tgdhtml/freenergy.html., 2023.

[K108] Pitkänen M. TGD and Nuclear Physics. In *TGD and Nuclear Physics*. *https: // tgdtheory. fi/ tgdhtml/ Bnucl. html*. Available at: https://tgdtheory.fi/pdfpool/padnucl.pdf, 2023.

[K109] Pitkänen M. TGD and Potential Anomalies of GRT. In *Physics in Many-Sheeted Space-Time: Part I*. *https: // tgdtheory. fi/ tgdhtml/ Btgdclass1. html*. Available at: https://tgdtheory.fi/pdfpool/granomalies.pdf., 2023.

[K110] Pitkänen M. TGD Based Model for OBEs. In *TGD Inspired Theory of Consciousness: Part III*. *https: // tgdtheory. fi/ tgdhtml/ Btgdconsc3. html*. Available at: https://tgdtheory.fi/pdfpool/OBE.pdf, 2023.

[K111] Pitkänen M. TGD Based View about Classical Fields in Relation to Consciousness Theory and Quantum Biology. In *TGD and Quantum Biology: Part I*. *https: // tgdtheory. fi/ tgdhtml/ Bqbio1. html*. Available at: https://tgdtheory.fi/pdfpool/maxtgdc.pdf, 2023.

[K112] Pitkänen M. *TGD Based View About Living Matter and Remote Mental Interactions*. Online book. Available at: https://www.tgdtheory.fi/tgdhtml/tgdlian.html, 2023.

[K113] Pitkänen M. *TGD Inspired Theory of Consciousness*. Online book. Available at: https://www.tgdtheory.fi/tgdhtml/tgdconsc.html., 2023.

[K114] Pitkänen M. The classical part of the twistor story. In *Quantum TGD: Part III*. *https: // tgdtheory. fi/ tgdhtml/ Btgdquantum3. html*. Available at: https://tgdtheory.fi/pdfpool/twistorstory.pdf, 2023.

[K115] Pitkänen M. The Geometry of the World of the Classical Worlds. In *Topological Geometrodynamics: Overview: Part I:https: // tgdtheory. fi/ tgdhtml/ Btgdview1. html*. Available at: https://tgdtheory.fi/pdfpool/tgdgeom.pdf, 2023.

[K116] Pitkänen M. The Notion of Wave-Genome and DNA as Topological Quantum Computer. In *Quantum - and Classical Computation in TGD Universe*. *https: // tgdtheory. fi/ tgdhtml/ Btgdcomp. html*. Available at: https://tgdtheory.fi/pdfpool/gari.pdf, 2023.

[K117] Pitkänen M. The Recent Status of Lepto-hadron Hypothesis. In *p-Adic Physics*. *https: // tgdtheory. fi/ tgdhtml/ Bpadphys. html*. Available at: https://tgdtheory.fi/pdfpool/leptc.pdf, 2023.

[K118] Pitkänen M. The Relationship Between TGD and GRT. In *Physics in Many-Sheeted Space-Time: Part I*. *https: // tgdtheory. fi/ tgdhtml/ Btgdclass1. html*. Available at: https://tgdtheory.fi/pdfpool/tgdgrt.pdf., 2023.

[K119] Pitkänen M. Three new physics realizations of the genetic code and the role of dark matter in bio-systems. In *Genes and Memes: Part II.* *https: // tgdtheory. fi/ tgdhtml/ Bgenememe2. html* . Available at: `https://tgdtheory.fi/pdfpool/dnatqccodes.pdf`, 2023.

[K120] Pitkänen M. *Topological Geometrodynamics.* Luniver Press. Available at: `https://tinyurl.com/hgd585n.`, 2023.

[K121] Pitkänen M. *Topological Geometrodynamics: an Overview.* Online book.Available at: `https://www.tgdtheory.fi/tgdhtml/tgdview.html.`, 2023.

[K122] Pitkänen M. Was von Neumann Right After All? In *TGD and Hyper-finite Factors.* *https: // tgdtheory. fi/ tgdhtml/ BHFF. html* . Available at: `https://tgdtheory.fi/pdfpool/vNeumann.pdf`, 2023.

[K123] Pitkänen M. WCW Spinor Structure. In *Quantum Physics as Infinite-Dimensional Geometry.* *https: // tgdtheory. fi/ tgdhtml/ Btgdgeom. html* . Available at: `https://tgdtheory.fi/pdfpool/cspin.pdf`, 2023.

[K124] Pitkänen M. Why TGD and What TGD is? In *Topological Geometrodynamics: an Overview.* *https: // tgdtheory. fi/ tgdhtml/ Btgdview1. html* . Available at: `https://tgdtheory.fi/pdfpool/WhyTGD.pdf`, 2023.

[K125] Pitkänen M. Wormhole Magnetic Fields. In *Bio-Systems as Self-Organizing Quantum Systems.* *https: // tgdtheory. fi/ tgdhtml/ BbioSO. html* . Available at: `https://tgdtheory.fi/pdfpool/wormc.pdf`, 2023.

[K126] Pitkänen M. Zero Energy Ontology. In *Quantum TGD: Part I.* *https: // tgdtheory. fi/ tgdhtml/ Btgdquantum1. html* . Available at: `https://tgdtheory.fi/pdfpool/ZEO.pdf`, 2023.

[K127] Gariaev P Pitkänen M. Quantum Model for Remote Replication. In *Genes and Memes: Part I.* *https: // tgdtheory. fi/ tgdhtml/ Bgenememe1. html* . Available at: `https://tgdtheory.fi/pdfpool/remotereplication.pdf`, 2023.

Articles about TGD

[L1] Pitkänen M. Biosystems as macroscopic quantum systems. *J Non-Locality & Remote Mental Interactions*, 2002.

[L2] Pitkänen M. Basic Properties of CP_2 and Elementary Facts about p-Adic Numbers. Available at: `https://tgdtheory.fi/pdfpool/append.pdf.`, 2006.

[L3] Pitkänen M. Further Progress in Nuclear String Hypothesis. Available at: `https://tgdtheory.fi/public_html/articles/nuclstring.pdf.`, 2007.

[L4] Pitkänen M. Quantum Model for Nerve Pulse and EEG . Available at: `https://tgdtheory.fi/public_html/articles/pulseeg.pdf.`, 2008.

[L5] Pitkänen M. TGD Inspired Quantum Model of Living Matter. Available at: `https://tgdtheory.fi/quantumbio.pdf.`, 2008.

[L6] Pitkänen M. DNA Waves and Water. Available at: `https://tgdtheory.fi/public_html/articles/mont.pdf.`, 2011.

[L7]   Pitkänen M. DNA Waves and Water. Available at: `https://tgdtheory.fi/public_html/articles/mont.pdf.`, 2011.

[L8]   Pitkänen M. Generalization of thermodynamics allowing negentropic entanglement and a model for conscious information processing. Available at: `https://tgdtheory.fi/public_html/articles/thermolife.pdf.`, 2011.

[L9]   Pitkänen M. Sheldrake's Morphic Fields and TGD View about Quantum Biology. Available at: `https://tgdtheory.fi/public_html/articles/sheldrake.pdf.`, 2011.

[L10] Pitkänen M. DNA and Water Memory: Comments on Montagnier Group's Recent Findings. *DNA Decipher Journal*, 1(1), 2011. See also `https://tgtheory.fi/public_html/articles/mont.pdf.`

[L11] Pitkänen M. How to build a quantum computer from magnetic flux tubes? Available at: `https://tgdtheory.fi/public_html/articles/fluxtubecomputer.pdf.`, 2012.

[L12] Pitkänen M. Quantum Model for the Direct Currents of Becker. Available at: `https://tgdtheory.fi/public_html/articles/DCbio.pdf.`, 2012.

[L13] Pitkänen M. A Vision about Quantum Jump as a Universal Cognitive Proces. Available at: `https://tgdtheory.fi/public_html/articles/hawkins.pdf.`, 2013.

[L14] Pitkänen M. About Concrete Realization of Remote Metabolism. Available at: `https://tgdtheory.fi/public_html/articles/teslaling.pdf.`, 2013.

[L15] Pitkänen M. Comparison of TGD inspired theory of consciousness with some other theories of consciousness, 2013.

[L16] Pitkänen M. Evolution in Many-Sheeted Space-Time: Big Vision. *DNA Decipher Journal*, 3(2), 2013. See also `https://tgtheory.fi/pdfpool/prebio.pdf.`

[L17] Pitkänen M. Evolution in Many-Sheeted Space-Time: Genetic Code. *DNA Decipher Journal*, 3(2), 2013. See also `https://tgtheory.fi/pdfpool/prebio.pdf.`

[L18] Pitkänen M. CMAP representations about TGD, and TGD inspired theory of consciousness and quantum biology. Available at: `https://www.tgdtheory.fi/tgdglossary.pdf.`, 2014.

[L19] Pitkänen M. Geometric theory of harmony. Available at: `https://tgdtheory.fi/public_html/articles/harmonytheory.pdf.`, 2014.

[L20] Pitkänen M. More Precise View about Remote Replication. Available at: `https://tgdtheory.fi/public_html/articles/dnabobs.pdf.`, 2014.

[L21] Pitkänen M. Morphogenesis, morphostasis, and learning in TGD framework. Available at: `https://tgdtheory.fi/public_html/articles/morpho.pdf.`, 2014.

[L22] Pitkänen M. New results about microtubules as quantum systems. Available at: `https://tgdtheory.fi/public_html/articles/microtubule.pdf.`, 2014.

[L23] Pitkänen M. Pollack's Findings about Fourth phase of Water : TGD View. Available at: `https://tgdtheory.fi/public_html/articles/PollackYoutube.pdf.`, 2014.

[L24] Pitkänen M. Music, Biology and Natural Geometry (Part I). *DNA Decipher Journal*, 4(2), 2014. See also `https://tgtheory.fi/public_html/articles/harmonytheory.pdf.`

[L25] Pitkänen M. Music, Biology and Natural Geometry (Part II). *DNA Decipher Journal*, 4(2), 2014. See also `https://tgtheory.fi/public_html/articles/harmonytheory.pdf.`

[L26] Pitkänen M. Jeremy England's vision about life and evolution: comparison with TGD approach . Available at: `https://tgdtheory.fi/public_html/articles/englandtgd.pdf.`, 2015.

[L27] Pitkänen M. Cold Fusion Again . Available at: `https://tgdtheory.fi/public_html/articles/cfagain.pdf.`, 2015.

[L28] Pitkänen M. Does the Physics of SmB6 Make the Fundamental Dynamics of TGD Directly Visible? 2015.

[L29] Pitkänen M. Maintenance problem for Earth's magnetic field. Available at: `https://tgdtheory.fi/public_html/articles/Bmaintenance.pdf.`, 2015.

[L30] Pitkänen M. Quantitative model of high T_c super-conductivity and bio-super-conductivity. Available at: `https://tgdtheory.fi/public_html/articles/newsupercond.pdf.`, 2015.

[L31] Pitkänen M. TGD based model for anesthetic action. Available at: `https://tgdtheory.fi/public_html/articles/anesthetes.pdf.`, 2015.

[L32] Pitkänen M. About high Tc superconductivity and other exotic conductivities . Available at: `https://tgdtheory.fi/public_html/articles/conductors.pdf.`, 2016.

[L33] Pitkänen M. About minimal surface extremals of Kähler action. Available at: `https://tgdtheory.fi/public_html/articles/minimalkahler.pdf.`, 2016.

[L34] Pitkänen M. About Physical Representations of Genetic Code in Terms of Dark Nuclear Strings. Available at: `https://tgdtheory.fi/public_html/articles/genecodemodels.pdf.`, 2016.

[L35] Pitkänen M. Bio-catalysis, morphogenesis by generalized Chladni mechanism, and bio-harmonies. Available at: `https://tgdtheory.fi/public_html/articles/chladnicata.pdf.`, 2016.

[L36] Pitkänen M. Can quantum biology really do without new physics? Available at: `https://tgdtheory.fi/public_html/articles/RPMTGD.pdf.`, 2016.

[L37] Pitkänen M. Comments about the representations in SSE-2016 conference about consciousness, biology, and paranormal phenomena. Available at: `https://tgdtheory.fi/public_html/articles/SSE.pdf.`, 2016.

[L38] Pitkänen M. Holography and Quantum Error Correcting Codes: TGD View. Available at: `https://tgdtheory.fi/public_html/articles/tensornet.pdf.`, 2016.

[L39] Pitkänen M. Hydrinos again. Available at: `https://tgdtheory.fi/public_html/articles/Millsagain.pdf.`, 2016.

[L40] Pitkänen M. What could be the physical origin of Pythagorean scale? Available at: `https://tgdtheory.fi/public_html/articles/geesinkscale.pdf.`, 2016.

[L41] Pitkänen M. What's new in TGD inspired view about phase transitions? . Available at: `https://tgdtheory.fi/public_html/articles/phasetransitions.pdf.`, 2016.

[L42] Pitkänen M. Artificial Intelligence, Natural Intelligence, and TGD. Available at: `https://tgdtheory.fi/public_html/articles/AITGD.pdf.`, 2017.

[L43] Pitkänen M. Cold fusion, low energy nuclear reactions, or dark nuclear synthesis? Available at: `https://tgdtheory.fi/public_html/articles/krivit.pdf.`, 2017.

[L44] Pitkänen M. DMT, pineal gland, and the new view about sensory perception. Available at: `https://tgdtheory.fi/public_html/articles/dmtpineal.pdf.`, 2017.

[L45] Pitkänen M. Does $M^8 - H$ duality reduce classical TGD to octonionic algebraic geometry? Available at: `https://tgdtheory.fi/public_html/articles/ratpoints.pdf.`, 2017.

[L46] Pitkänen M. Does valence bond theory relate to the hierarchy of Planck constants? Available at: `https://tgdtheory.fi/public_html/articles/valenceheff.pdf.`, 2017.

[L47] Pitkänen M. Life-like properties observed in a very simple system. Available at: `https://tgdtheory.fi/public_html/articles/plasticballs.pdf`., 2017.

[L48] Pitkänen M. Mysteriously disappearing valence electrons of rare Earth metals and hierarchy of Planck constants. Available at: `https://tgdtheory.fi/public_html/articles/rareearth.pdf`., 2017.

[L49] Pitkänen M. p-Adicization and adelic physics. Available at: `https://tgdtheory.fi/public_html/articles/adelicphysics.pdf`., 2017.

[L50] Pitkänen M. Philosophy of Adelic Physics. In *Trends and Mathematical Methods in Interdisciplinary Mathematical Sciences*, pages 241–319. Springer.Available at: `https://link.springer.com/chapter/10.1007/978-3-319-55612-3_11`, 2017.

[L51] Pitkänen M. Philosophy of Adelic Physics. Available at: `https://tgdtheory.fi/public_html/articles/adelephysics.pdf`., 2017.

[L52] Pitkänen M. Questions about twistor lift of TGD. Available at: `https://tgdtheory.fi/public_html/articles/twistquestions.pdf`., 2017.

[L53] Pitkänen M. Re-examination of the basic notions of TGD inspired theory of consciousness. Available at: `https://tgdtheory.fi/public_html/articles/conscrit.pdf`., 2017.

[L54] Pitkänen M. About dark variants of DNA, RNA, and amino-acids. Available at: `https://tgdtheory.fi/public_html/articles/darkvariants.pdf`., 2018.

[L55] Pitkänen M. About the Correspondence of Dark Nuclear Genetic Code and Ordinary Genetic Code. Available at: `https://tgdtheory.fi/public_html/articles/codedarkcode.pdf`., 2018.

[L56] Pitkänen M. About the physical interpretation of the velocity parameter in the formula for the gravitational Planck constant . Available at: `https://tgdtheory.fi/public_html/articles/vzero.pdf`., 2018.

[L57] Pitkänen M. Could also RNA and protein methylation of RNA be involved with the expression of molecular emotions? Available at: `https://tgdtheory.fi/public_html/articles/synapticmoods.pdf`., 2018.

[L58] Pitkänen M. Could cancer be a disease of magnetic body? Available at: `https://tgdtheory.fi/public_html/articles/nanotesla.pdf`., 2018.

[L59] Pitkänen M. Dark valence electrons and color vision. Available at: `https://tgdtheory.fi/public_html/articles/colorvision.pdf`., 2018.

[L60] Pitkänen M. Did RNA Replicate in Codon-Wise Manner during RNA Era? Available at: `hhttps://tgtheory.fi/public_html/articles/RNAreplication.pdf`., 2018.

[L61] Pitkänen M. Emotions as sensory percepts about the state of magnetic body? Available at: `https://tgdtheory.fi/public_html/articles/emotions.pdf`., 2018.

[L62] Pitkänen M. Expanding Earth Model and Pre-Cambrian Evolution of Continents, Climate, and Life. Available at: `https://tgdtheory.fi/public_html/articles/expearth.pdf`., 2018.

[L63] Pitkänen M. Five new strange effects associated with galaxies. Available at: `https://tgdtheory.fi/public_html/articles/3galeffects.pdf`., 2018.

[L64] Pitkänen M. Getting philosophical: some comments about the problems of physics, neuroscience, and biology. Available at: `https://tgdtheory.fi/public_html/articles/philosophic.pdf`., 2018.

[L65] Pitkänen M. Homonymy of the genetic code from TGD point of view. Available at: `https://tgdtheory.fi/public_html/articles/homonymy.pdf`., 2018.

[L66] Pitkänen M. Maxwell's lever rule and expansion of water in freezing: two poorly understood phenomena. Available at: `https://tgdtheory.fi/public_html/articles/leverule.pdf`., 2018.

[L67] Pitkänen M. Morphogenesis in TGD Universe. Available at: `https://tgdtheory.fi/public_html/articles/morphoTGD.pdf`., 2018.

[L68] Pitkänen M. New insights about quantum criticality for twistor lift inspired by analogy with ordinary criticality. Available at: `https://tgdtheory.fi/public_html/articles/zeocriticality.pdf`., 2018.

[L69] Pitkänen M. New results in the model of bio-harmony. Available at: `https://tgdtheory.fi/public_html/articles/harmonynew.pdf`., 2018.

[L70] Pitkänen M. Sensory perception and motor action as time reversals of each other: a royal road to the understanding of other minds? Available at: `https://tgdtheory.fi/public_html/articles/timemirror.pdf`., 2018.

[L71] Pitkänen M. TGD view about coupling constant evolution. Available at: `https://tgdtheory.fi/public_html/articles/ccevolution.pdf`., 2018.

[L72] Pitkänen M. TGD view about quasars. Available at: `https://tgdtheory.fi/public_html/articles/meco.pdf`., 2018.

[L73] Pitkänen M. The Recent View about Twistorialization in TGD Framework. Available at: `https://tgdtheory.fi/public_html/articles/smatrix.pdf`., 2018.

[L74] Pitkänen M. On the Correspondence of Dark Nuclear Genetic Code & Ordinary Genetic Code. *DNA Decipher Journal*, 8(1), 2018. See also `https://tgtheory.fi/public_html/articles/codedarkcode.pdf`.

[L75] Pitkänen M. An overall view about models of genetic code and bio-harmony. Available at: `https://tgdtheory.fi/public_html/articles/gcharm.pdf`., 2019.

[L76] Pitkänen M. Are fundamental entities discrete or continous and what discretization at fundamental level could mean? Available at: `https://tgdtheory.fi/public_html/articles/zetaspecu.pdf`., 2019.

[L77] Pitkänen M. Copenhagen interpretation dead: long live ZEO based quantum measurement theory! Available at: `https://tgdtheory.fi/public_html/articles/Bohrdead.pdf`., 2019.

[L78] Pitkänen M. Cosmic string model for the formation of galaxies and stars. Available at: `https://tgdtheory.fi/public_html/articles/galaxystars.pdf`., 2019.

[L79] Pitkänen M. Cosmology in crisis. Available at: `https://tgdtheory.fi/public_html/articles/cosmocrisis.pdf`., 2019.

[L80] Pitkänen M. Could Mars have intra-planetary life? Available at: `https://tgdtheory.fi/public_html/articles/Mars.pdf`., 2019.

[L81] Pitkänen M. Earhquakes and volcanic eruptions as macroscopic quantum jumps in zero energy ontology. Available at: `https://tgdtheory.fi/public_html/articles/earthquakes.pdf`., 2019.

[L82] Pitkänen M. Epigenesis, inherited memories and moods lasting over several generations. Available at: `https://tgdtheory.fi/public_html/articles/amoebamemory.pdf`., 2019.

[L83] Pitkänen M. $M^8 - H$ duality and consciousness. Available at: `https://tgdtheory.fi/public_html/articles/M8Hconsc.pdf`., 2019.

[L84] Pitkänen M. Minimization of Gibbs free energy as thermodynamical variational principle in TGD framework. Available at: `https://tgdtheory.fi/public_html/articles/hydrophoby.pdf`., 2019.

[L85] Pitkänen M. Multilocal viruses. Available at: `https://tgdtheory.fi/public_html/articles/viralstrange.pdf.`, 2019.

[L86] Pitkänen M. New results related to $M^8 - H$ duality. Available at: `https://tgdtheory.fi/public_html/articles/M8Hduality.pdf.`, 2019.

[L87] Pitkänen M. Quantum self-organization by h_{eff} changing phase transitions. Available at: `https://tgdtheory.fi/public_html/articles/heffselforg.pdf.`, 2019.

[L88] Pitkänen M. Scattering amplitudes and orbits of cognitive representations under subgroup of symplectic group respecting the extension of rationals . Available at: `https://tgdtheory.fi/public_html/articles/symplorbsm.pdf.`, 2019.

[L89] Pitkänen M. Solar Metallicity Problem from TGD Perspective. Available at: `https://tgdtheory.fi/public_html/articles/darkcore.pdf.`, 2019.

[L90] Pitkänen M. Solar Surprise. Available at: `https://tgdtheory.fi/public_html/articles/solarsycle.pdf.`, 2019.

[L91] Pitkänen M. Some applications of TGD inspired quantum biology: bio-chemistry, metabolism, replication. Available at: `https://tgdtheory.fi/public_html/articles/bioexamples.pdf.`, 2019.

[L92] Pitkänen M. Some comments related to Zero Energy Ontology (ZEO). Available at: `https://tgdtheory.fi/public_html/articles/zeoquestions.pdf.`, 2019.

[L93] Pitkänen M. Tesla still inspires. Available at: `https://tgdtheory.fi/public_html/articles/teslastill.pdf.`, 2019.

[L94] Pitkänen M. Waterbridge experiment from TGD point of view. Available at: `https://tgdtheory.fi/public_html/articles/waterbridge.pdf.`, 2019.

[L95] Pitkänen M. An Overall View about Models of Genetic Code & Bio-harmony. *DNA Decipher Journal*, 9(2), 2019. See also `https://tgtheory.fi/public_html/articles/gcharm.pdf.`

[L96] Pitkänen M. A critical re-examination of $M^8 - H$ duality hypothesis: part I. Available at: `https://tgdtheory.fi/public_html/articles/M8H1.pdf.`, 2020.

[L97] Pitkänen M. A critical re-examination of $M^8 - H$ duality hypothesis: part II. Available at: `https://tgdtheory.fi/public_html/articles/M8H2.pdf.`, 2020.

[L98] Pitkänen M. A model of protocell based on Pollack effect. Available at: `https://tgdtheory.fi/public_html/articles/pollackoparin.pdf.`, 2020.

[L99] Pitkänen M. Could brain be represented as a hyperbolic geometry? Available at: `https://tgdtheory.fi/public_html/articles/hyperbolicbrain.pdf.`, 2020.

[L100] Pitkänen M. Could quantum randomness have something to do with classical chaos? Available at: `https://tgdtheory.fi/public_html/articles/chaostgd.pdf.`, 2020.

[L101] Pitkänen M. How to compose beautiful music of light in bio-harmony? `https://tgdtheory.fi/public_html/articles/bioharmony2020.pdf.`, 2020.

[L102] Pitkänen M. New results about dark DNA inspired by the model for remote DNA replication. Available at: `https://tgdtheory.fi/public_html/articles/darkdnanew.pdf.`, 2020.

[L103] Pitkänen M. The dynamics of SSFRs as quantum measurement cascades in the group algebra of Galois group. Available at: `https://tgdtheory.fi/public_html/articles/SSFRGalois.pdf.`, 2020.

[L104] Pitkänen M. Results about Dark DNA & Remote DNA Replication. *DNA Decipher Journal*, 10(1), 2020. See also `https://tgtheory.fi/public_html/articles/darkdnanew.pdf.`

[L105] Pitkänen M. The Dynamics of State Function Reductions as Quantum Measurement Cascades. *Pre-Space-Time Journal*, 11(2), 2020. See also `https://tgtheory.fi/public_html/articles/SSFRGalois.pdf`.

[L106] Pitkänen M. About the role of Galois groups in TGD framework. `https://tgdtheory.fi/public_html/articles/GaloisTGD.pdf`., 2021.

[L107] Pitkänen M. EEG and the structure of magnetosphere. `https://tgdtheory.fi/public_html/articles/mseeg.pdf`., 2021.

[L108] Pitkänen M. Is genetic code part of fundamental physics in TGD framework? Available at: `https://tgdtheory.fi/public_html/articles/TIH.pdf`., 2021.

[L109] Pitkänen M. Revolution in chemistry. `https://tgdtheory.fi/public_html/articles/newchemistry.pdf`., 2021.

[L110] Pitkänen M. Some questions concerning zero energy ontology. `https://tgdtheory.fi/public_html/articles/zeonew.pdf`., 2021.

[L111] Pitkänen M. TGD as it is towards the end of 2021. `https://tgdtheory.fi/public_html/articles/TGD2021.pdf`., 2021.

[L112] Pitkänen M. Time reversal and the anomalies of rotating magnetic systems. Available at: `https://tgdtheory.fi/public_html/articles/freereverse.pdf`., 2021.

[L113] Pitkänen M. What could 2-D minimal surfaces teach about TGD? `https://tgdtheory.fi/public_html/articles/minimal.pdf`., 2021.

[L114] Pitkänen M. About TGD counterparts of twistor amplitudes: part I. `https://tgdtheory.fi/public_html/articles/twisttgd1.pdf`., 2022.

[L115] Pitkänen M. About TGD counterparts of twistor amplitudes: part II. `https://tgdtheory.fi/public_html/articles/twisttgd2.pdf`., 2022.

[L116] Pitkänen M. Comparison of Orch-OR hypothesis with the TGD point of view. `https://tgdtheory.fi/public_html/articles/penrose.pdf`., 2022.

[L117] Pitkänen M. Finite Fields and TGD. `https://tgdtheory.fi/public_html/articles/finitefieldsTGD.pdf`., 2022.

[L118] Pitkänen M. Hen and egg problems of biology from TGD point of view. `https://tgdtheory.fi/public_html/articles/henegg.pdf`., 2022.

[L119] Pitkänen M. How animals without brain can behave as if they had brain. `https://tgdtheory.fi/public_html/articles/precns.pdf`., 2022.

[L120] Pitkänen M. Intersection form for 4-manifolds, knots and 2-knots, smooth exotics, and TGD. `https://tgdtheory.fi/public_html/articles/finitefieldsTGD.pdf`., 2022.

[L121] Pitkänen M. Some New Ideas Related to Langlands Program *viz.* TGD. `https://tgdtheory.fi/public_html/articles/Langlands2022.pdf`., 2022.

[L122] Pitkänen M. TGD view about water memory and the notion of morphogenetic field . `https://tgdtheory.fi/public_html/articles/watermorpho.pdf`., 2022.

[L123] Pitkänen M. The realization of genetic code in terms of dark nucleon and dark photon triplets. `https://tgdtheory.fi/public_html/articles/darkcode.pdf`., 2022.

[L124] Pitkänen M. Trying to fuse the basic mathematical ideas of quantum TGD to a single coherent whole. `https://tgdtheory.fi/public_html/articles/fusionTGD.pdf`., 2022.

[L125] Pitkänen M. Two objections against p-adic thermodynamics and their resolution. `https://tgdtheory.fi/public_html/articles/padmass2022.pdf`., 2022.

[L126] Pitkänen M. About tessellations in hyperbolic 3-space and their relation to the genetic code . `https://tgdtheory.fi/public_html/articles/tessellationH3.pdf.`, 2023.

[L127] Pitkänen M. About long range electromagnetic quantum coherence in TGD Universe. `https://tgdtheory.fi/public_html/articles/hem.pdf.`, 2023.

[L128] Pitkänen M. About the mechanism of the energy transfer in photosynthesis. `https://tgdtheory.fi/public_html/articles/photosynth.pdf.`, 2023.

[L129] Pitkänen M. Are Conscious Computers Possible in TGD Universe? `https://tgdtheory.fi/public_html/articles/tgdcomp.pdf.`, 2023.

[L130] Pitkänen M. Could neuronal system and even GPT give rise to a computer with a variable arrow of time? `https://tgdtheory.fi/public_html/articles/GPT.pdf.`, 2023.

[L131] Pitkänen M. Holography and Hamilton-Jacobi Structure as 4-D generalization of 2-D complex structure. `https://tgdtheory.fi/public_html/articles/HJ.pdf.`, 2023.

[L132] Pitkänen M. Is Negentropy Maximization Principle needed as an independent principle? `https://tgdtheory.fi/public_html/articles/NMPcrit.pdf.`, 2023.

[L133] Pitkänen M. New result about causal diamonds from the TGD view point of view. `https://tgdtheory.fi/public_html/articles/CDconformal.pdf.`, 2023.

[L134] Pitkänen M. Pollack effect, lightnings and ball lightnings. `https://tgdtheory.fi/public_html/articles/balllightning.pdf.`, 2023.

[L135] Pitkänen M. Reduction of standard model structure to CP_2 geometry and other key ideas of TGD. `https://tgdtheory.fi/public_html/articles/cp2etc.pdf.`, 2023.

[L136] Pitkänen M. Symmetries and Geometry of the "World of Classical Worlds" . `https://tgdtheory.fi/public_html/articles/wcwsymm.pdf.`, 2023.

[L137] Pitkänen M. TGD view of Michael Levin's work. `https://tgdtheory.fi/public_html/articles/Levin.pdf.`, 2023.

[L138] Pitkänen M. A fresh look at $M^8 - H$ duality and Poincare invariance. `https://tgdtheory.fi/public_html/articles/TGDcritics.pdf.`, 2024.

[L139] Pitkänen M. About the Recent TGD Based View Concerning Cosmology and Astrophysics. `https://tgdtheory.fi/public_html/articles/3pieces.pdf.`, 2024.

[L140] Pitkänen M. Modified Dirac equation and the holography=holomorphy hypothesis. `https://tgdtheory.fi/public_html/articles/modDir.pdf.`, 2024.

[L141] Pitkänen M. What gravitons are and could one detect them in TGD Universe? `https://tgdtheory.fi/public_html/articles/whatgravitons.pdf.`, 2024.

[L142] Pitkänen M and Rastmanesh R. Homeostasis as self-organized quantum criticality. Available at: `https://tgdtheory.fi/public_html/articles/SP.pdf.`, 2020.

[L143] Pitkänen M and Rastmanesh R. New Physics View about Language: part I. Available at: `https://tgdtheory.fi/public_html/articles/languageTGD1.pdf.`, 2020.

[L144] Pitkänen M and Rastmanesh R. New Physics View about Language: part II. Available at: `https://tgdtheory.fi/public_html/articles/languageTGD2.pdf.`, 2020.

[L145] Pitkänen M and Rastmanesh R. The based view about dark matter at the level of molecular biology. Available at: `https://tgdtheory.fi/public_html/articles/darkchemi.pdf.`, 2020.

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