TGD AND EEG: 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. 23**). 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 $H = M^4 \times CP_2$ [L115]. 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 [L40, L55](see **Fig. 24**). 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. 25**). The mere mathematical existence of WCW geometry requires that it has maximal isometries, which together twistor lift and number theoretic vision fixes it uniquely [L118].

- 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 [K115, L63].

- 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 [K26, K58] [L97].

- 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 [L107]. 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 [L125].

- 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 [L38, L39] 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. 26**). 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 [L120]. 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. 27**). 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. 28**), 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. 29**).

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. 30**).

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. 31** and **Fig. 32**). 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. 33**). 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 [L92], 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 [A9]. I have proposed [K51, K29, K112, K83, L118] 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 [K115, L63] 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 [L112]. 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 [L85, L86] 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 [L125].

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 [L100]. 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.

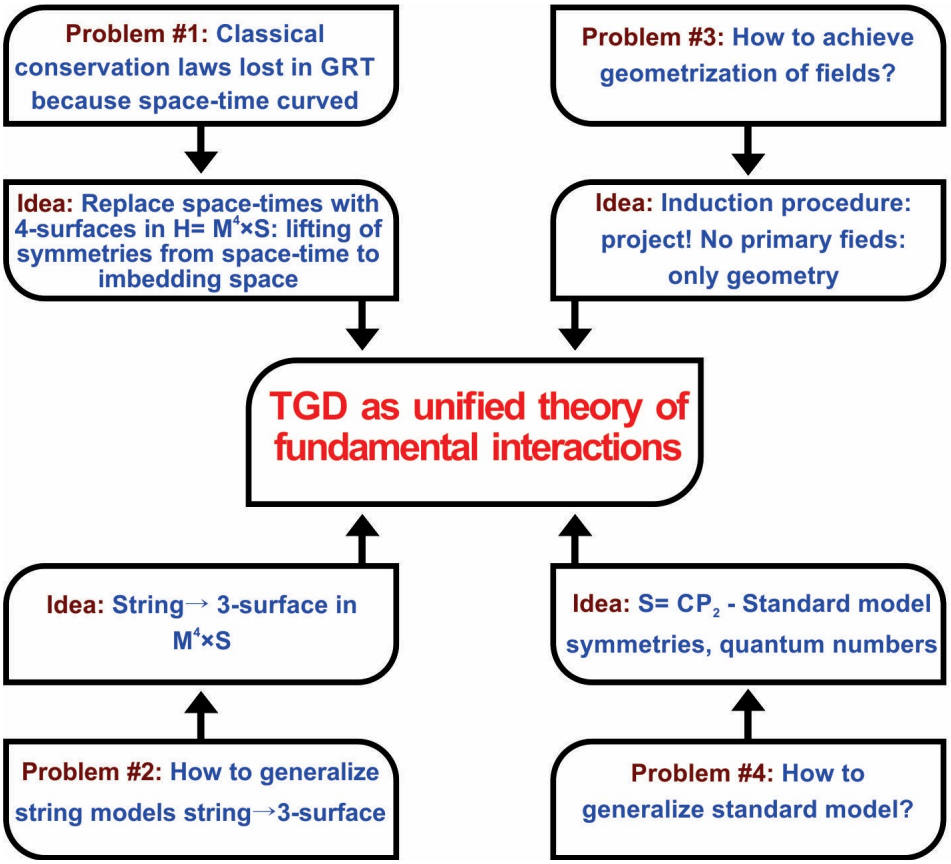

Figure 1: The problems leading to TGD as their solution.

- 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.

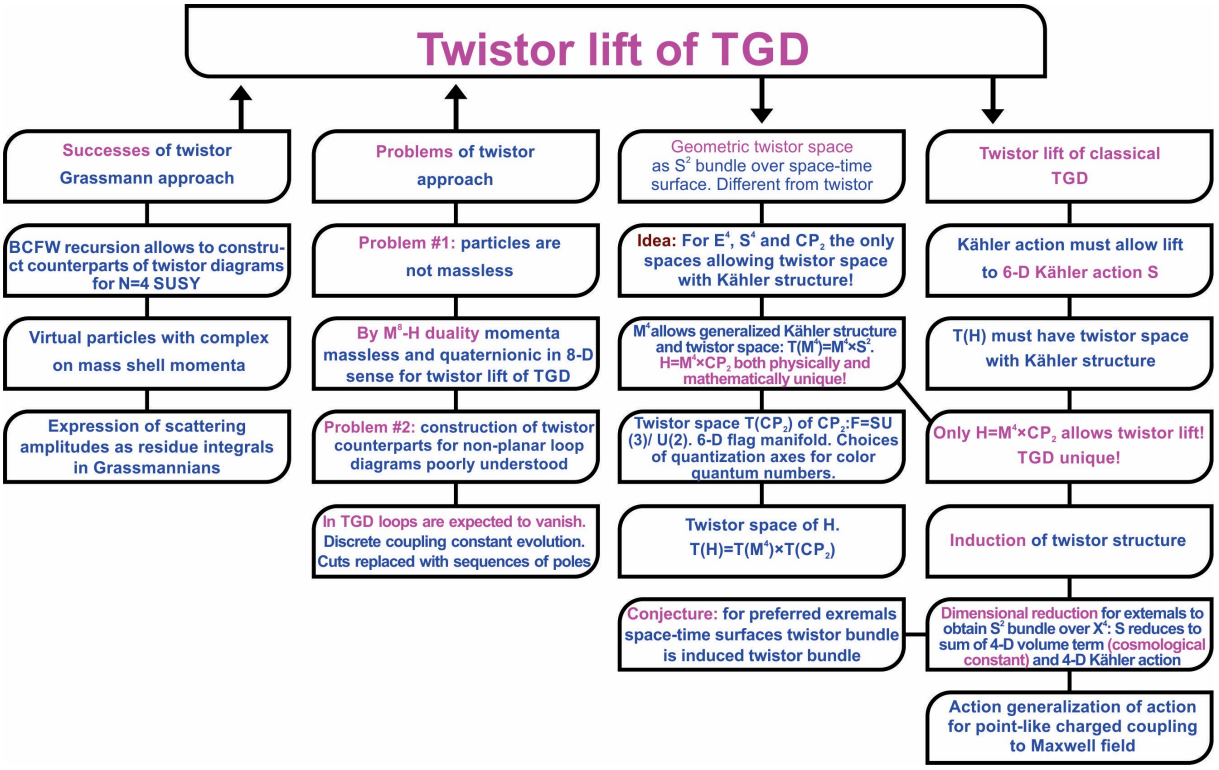

Figure 2: Twistor lift

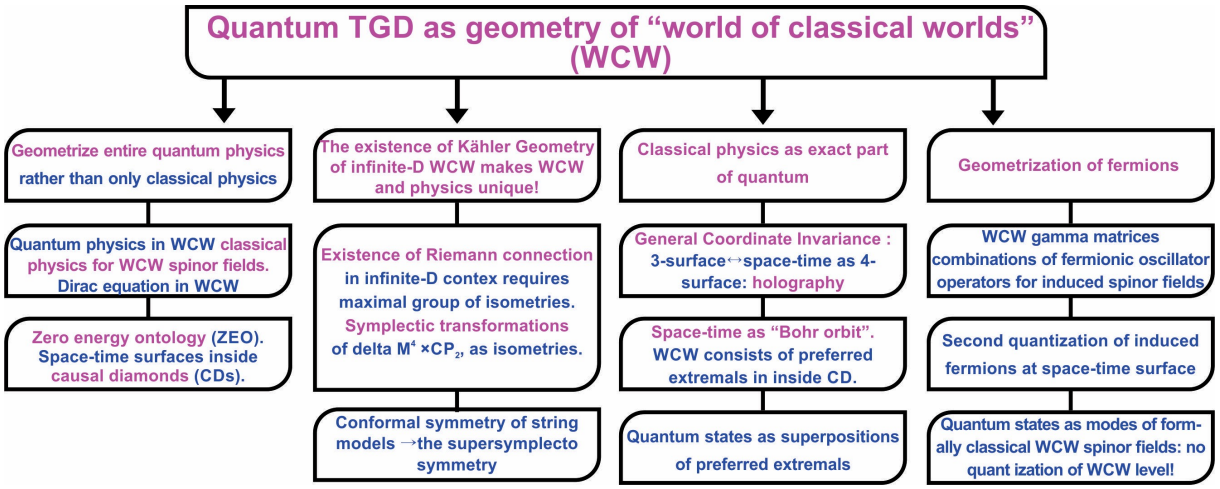

Figure 3: Geometrization of quantum physics in terms of WCW

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

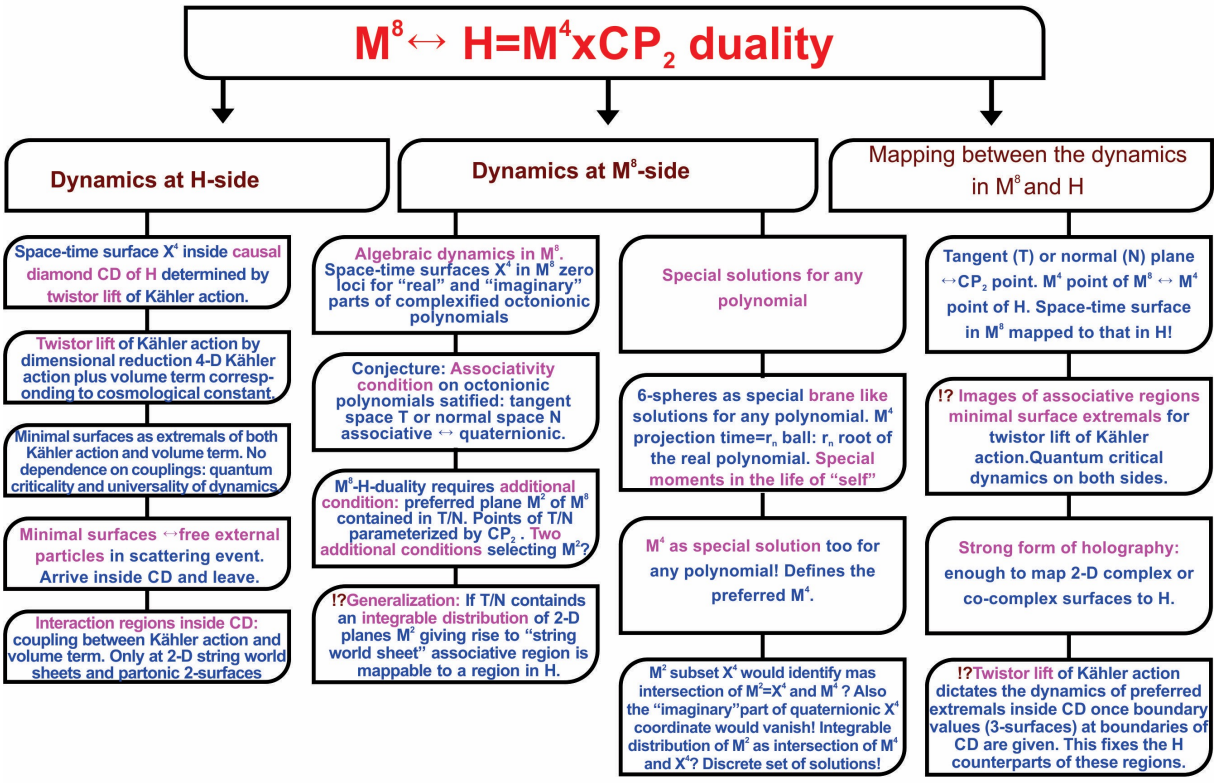

Figure 4: $M^8 - H$ duality

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

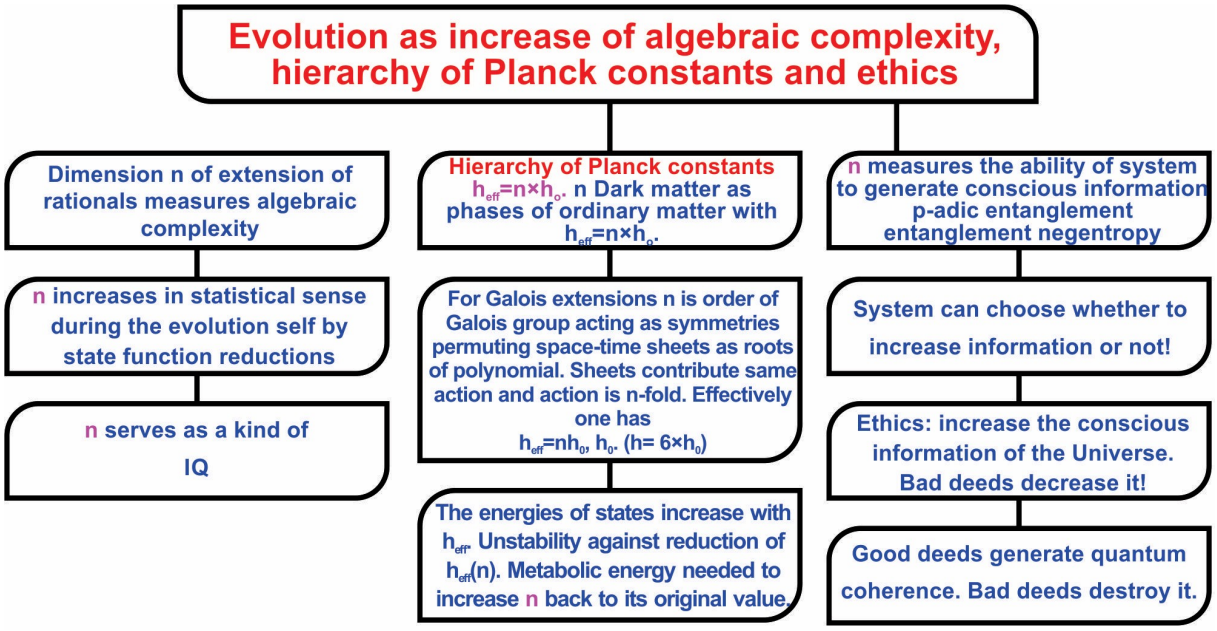

Figure 5: Number theoretic view of evolution

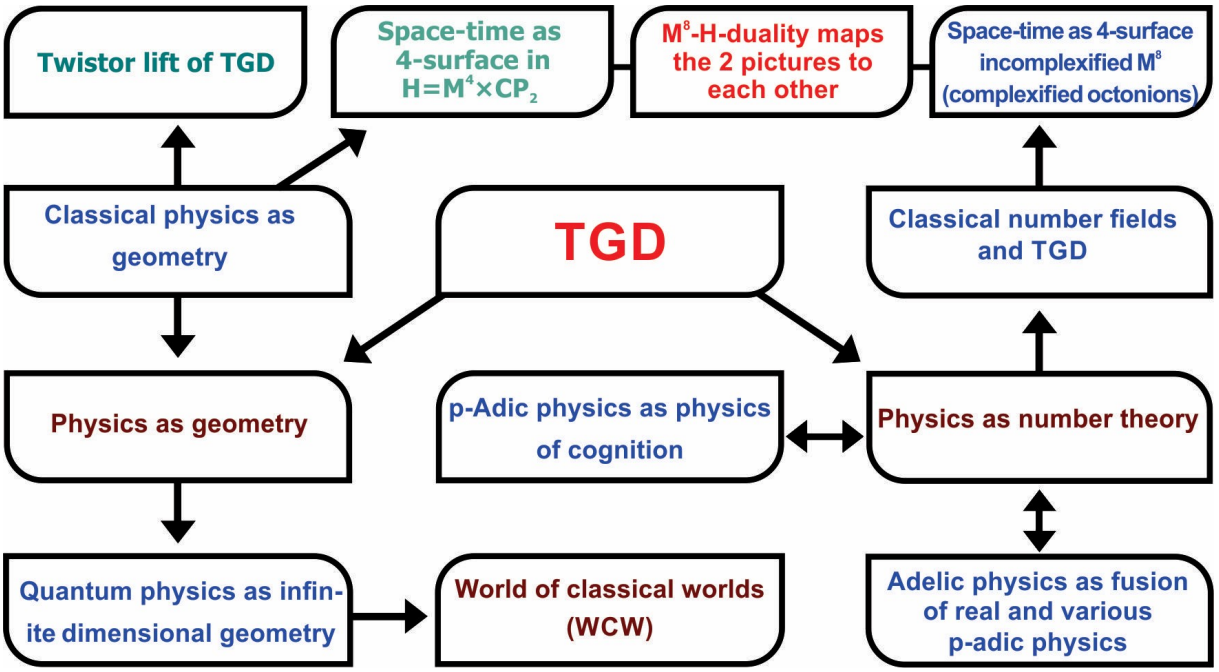

Figure 6: TGD is based on two complementary visions: physics as geometry and physics as number theory.

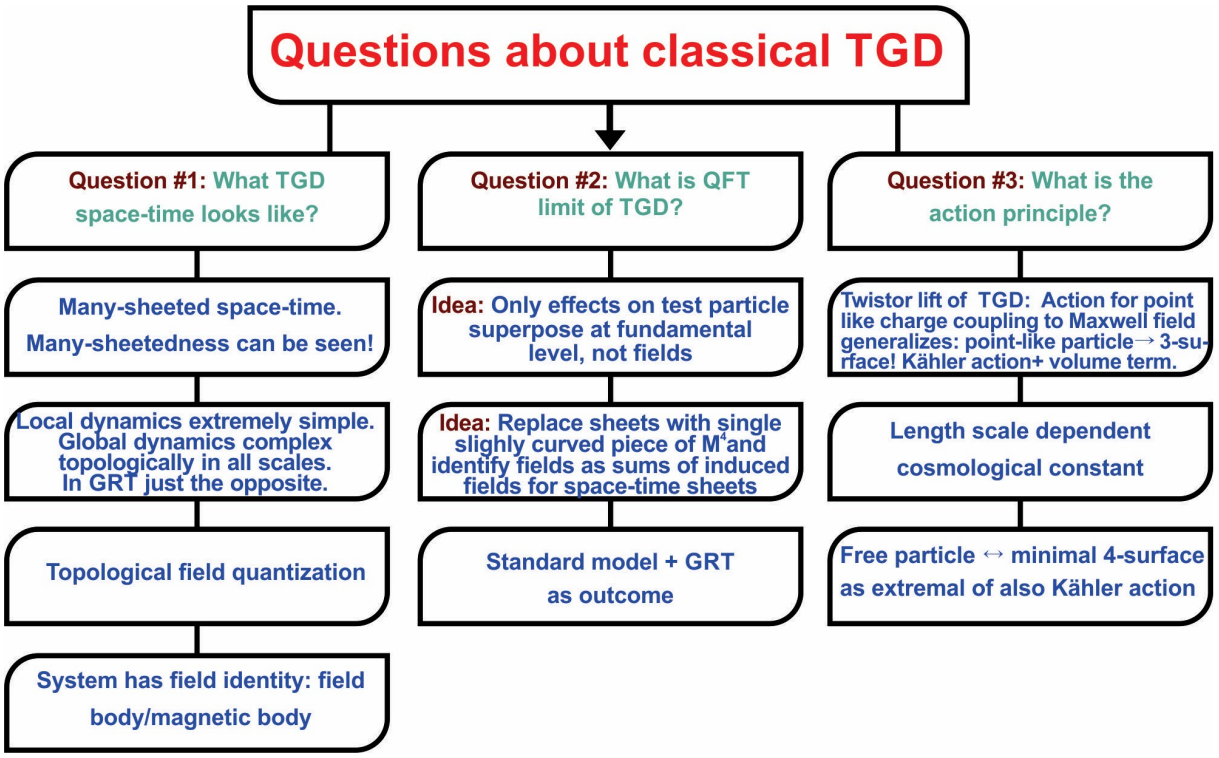

Figure 7: Questions about classical TGD.

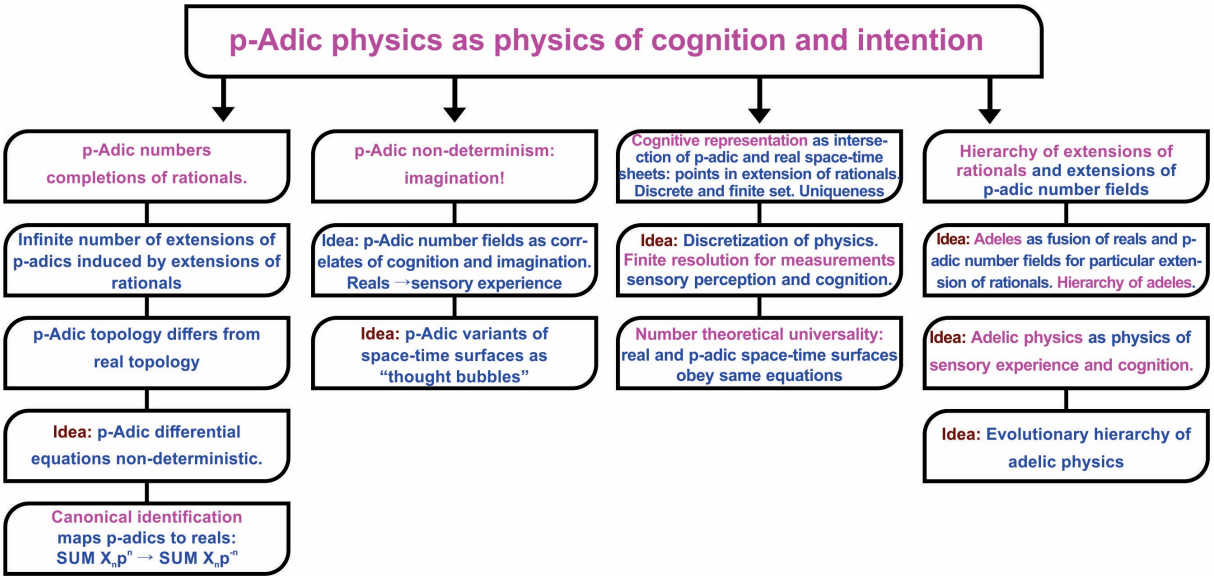

Figure 8: p-Adic physics as physics of cognition and imagination.

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 constant 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.

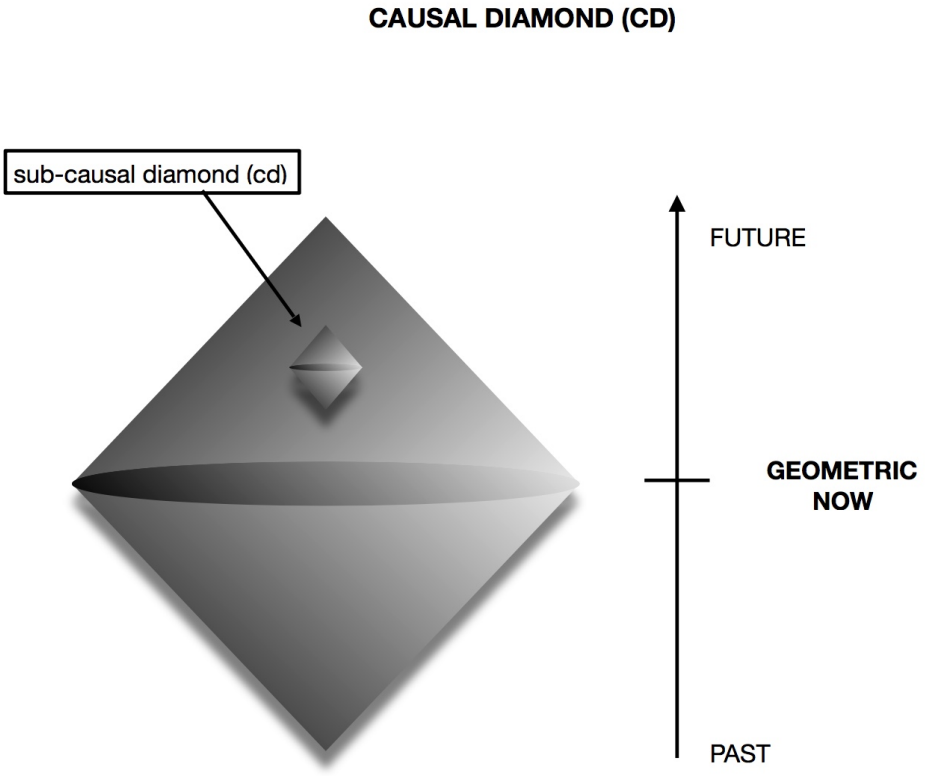

Figure 9: Causal diamond

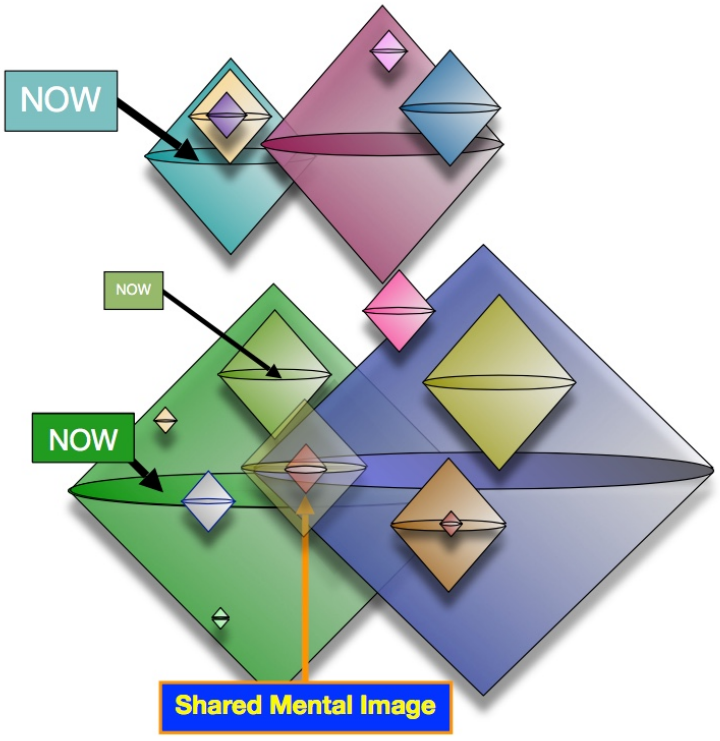

Figure 10: CDs define a fractal "conscious atlas"

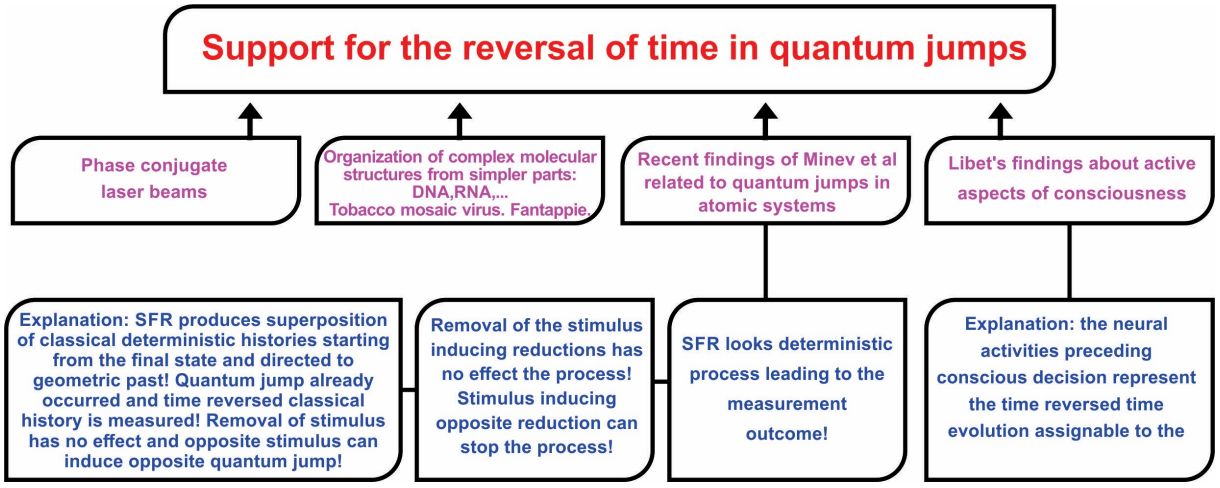

Figure 11: Time reversal occurs in BSFR

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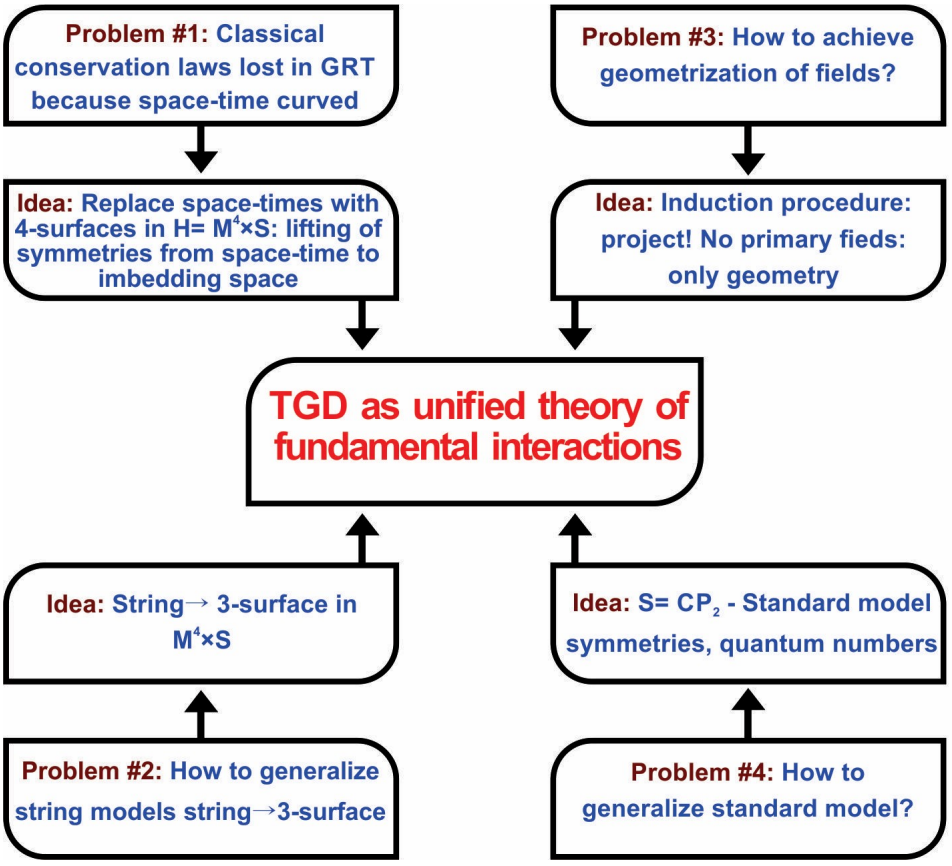


Figure 12: The problems leading to TGD as their solution.

TGD view of consciousness very briefly

The following is a very brief summary of the basic notions and ideas of TGD inspired theory of consciousness.

- TGD inspired theory of consciousness can be seen as a generalization of quantum measurement theory by bringing in the conscious observer. One can even say that Quantum TGD is basically a theory of conscious experience.

  The basic new elements are the resolution of the basic problem of the measurement theory by the introduction of ZEO, which brings new elements also to the quantum measurement theory and leads to a view about how the arrow of time and its flow are generated. Number theoretic physics brings in p-adic physics and the notion of negentropic entanglement. Negentropy Maximization Principle (NMP) was first proposed to serve as a variational principle of consciousness but turned out to follow from number theoretical evolution as a mathematical analog of the second law and implying it. The possibility of negentropic entanglement indeed predicts evolution as gradual increase of negentropic resources of the Universe.

- There are two kinds of state function reductions: the "small" ones (SSFRs) and the "big" ones (BSFRs). The sequence of SSFRs is the counterpart for the repeated measurements of the same observables or at least for a sequence involving measurements of sets of mutually commuting observables such that these sets commute with each other. The state function

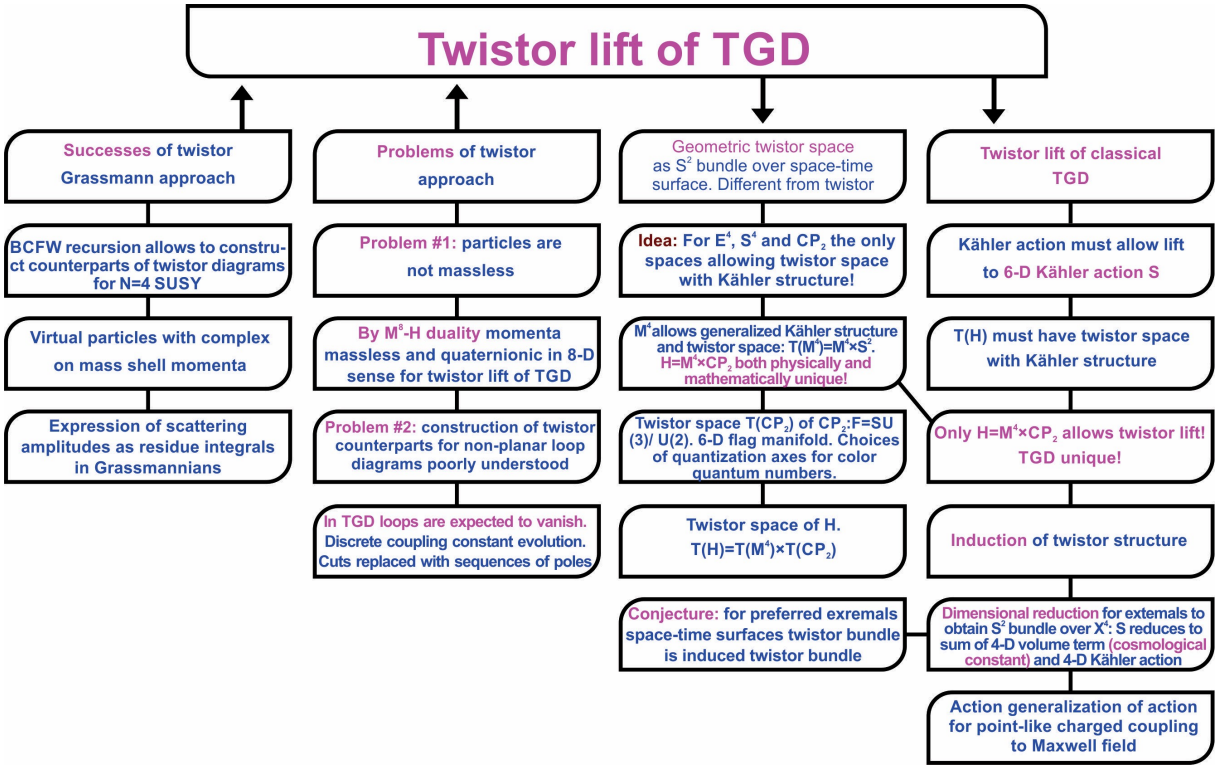


Figure 13: Twistor lift

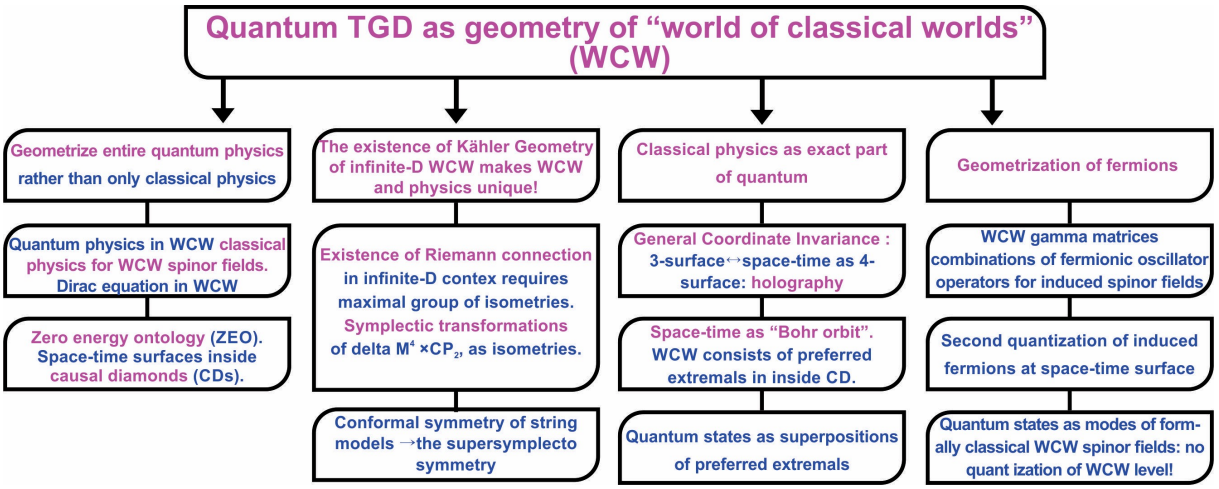


Figure 14: Geometrization of quantum physics in terms of WCW

reductions which leave invariant only the second part of the zero energy state but change the other one: this is the counterpart of the Zeno effect.

Self can be identified as the sequence of SSFRs preceded by the TGD counterparts of unitary time evolutions. The generation of "Akashic records" defined by negentropically entangled systems plays a vital role in the understanding of evolution.

When the set of observables measured in does not commute with the preceding set, SSFR is not possible and BSFR occurs and changes the arrow of time. The roles of the boundaries of CD are changed. Self reincarnates with an opposite arrow of time. Since the classical signals generated by self propagate to opposite time direction, "classical" memories about this period are not possible.

This prediction is something totally new and profoundly affects the view of physics even in cosmological scales since the hierarchy of effective Planck constants allows quantum coherence and consciousness are therefore possible in all scales. For the outsider BSFR looks like a loss of consciousness, death, or falling asleep. The system starts to live consciously in the opposite time direction and reincarnates in the next BSFR.

The strongest simplifying assumption is that the size of CD increases steadily in the sequences of SSFRs. A more precise view is achieved by introducing the finite-dimensional space of CDs. A given SSFR is preceded by a TGD counterpart of a unitary time evolution as a dispersion in the space of CDs. SSFR means a localization in this moduli space and implies the statistical increase of the size CD and the correlation between experienced time as sequence of SSFRs with the geometric time identifiable as the distance between the tips of CD.

- CDs serve as correlates of selves and a hierarchy of selves is predicted and closely relates to

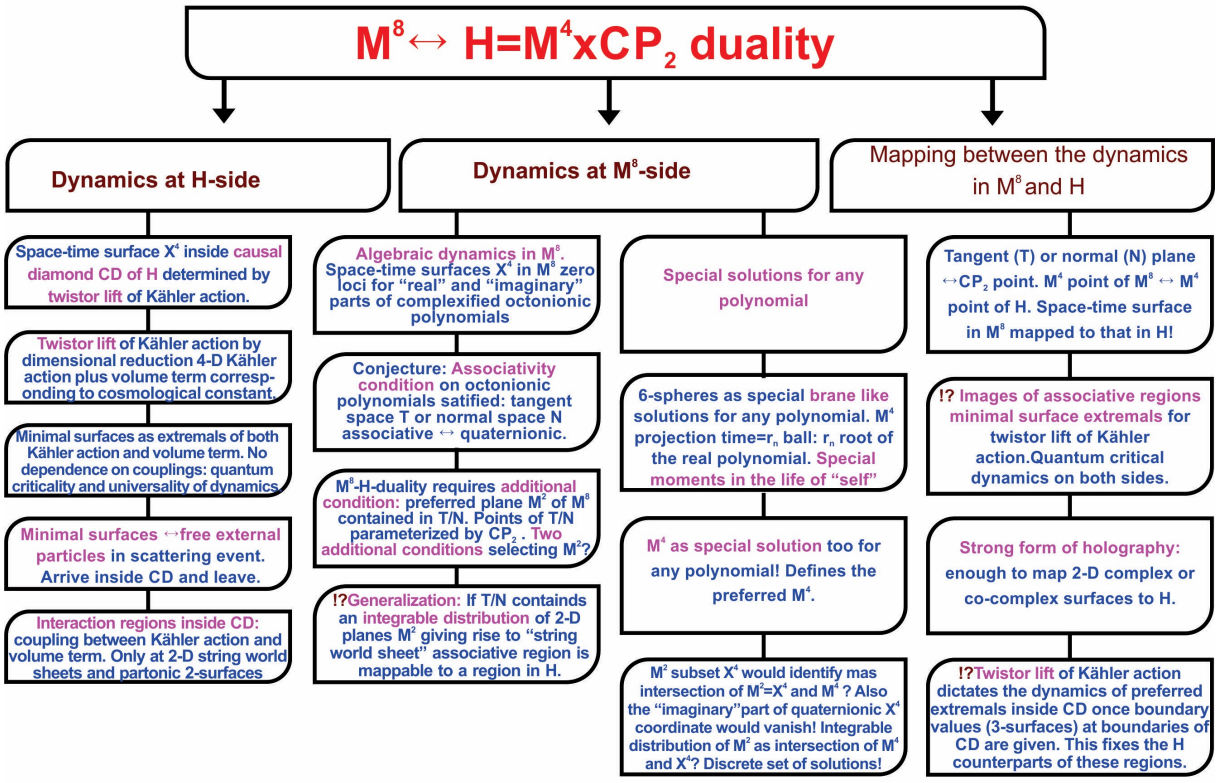


Figure 15: $M^8 - H$ duality

the p-adic hierarchy and hierarchy of Planck constants. Subselves are interpreted as mental images of self and the sharing of mental images by fusion of subselves gives rise to a kind of stereo consciousness.

Figures

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

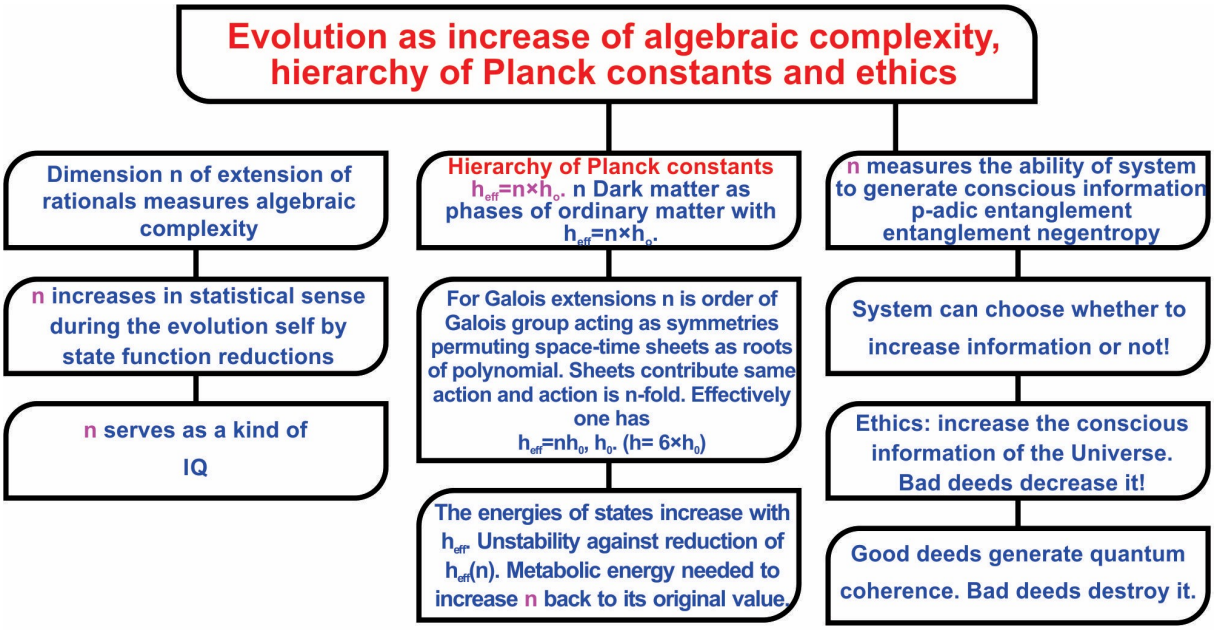
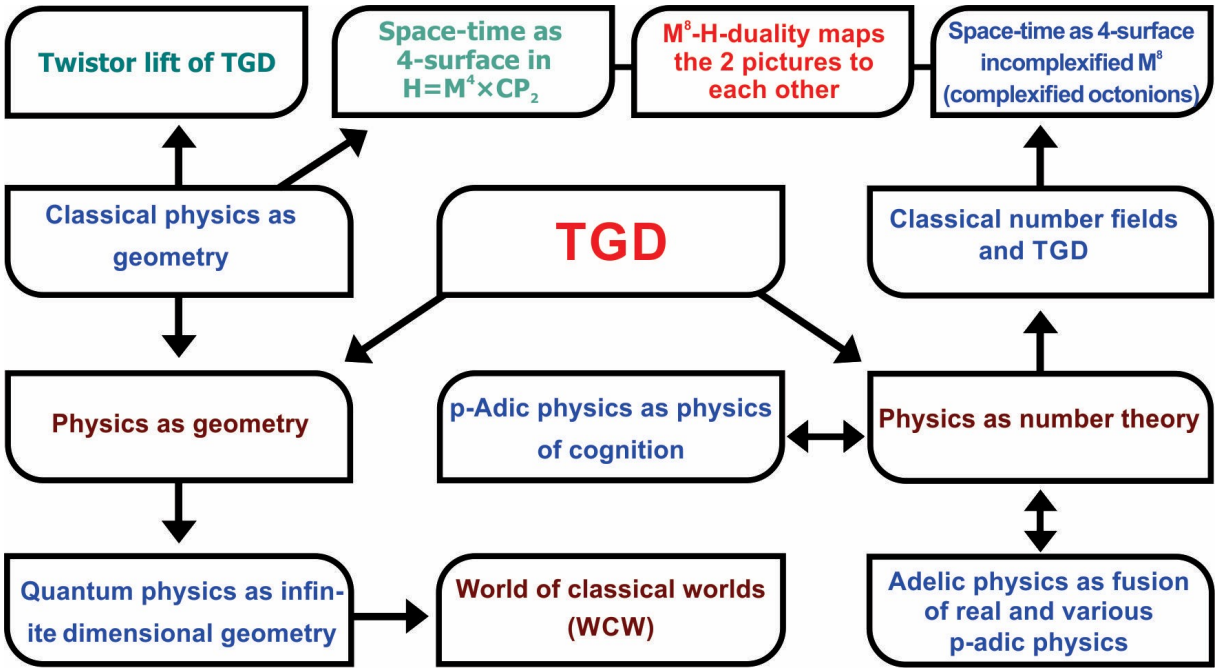


Figure 16: Number theoretic view of evolution



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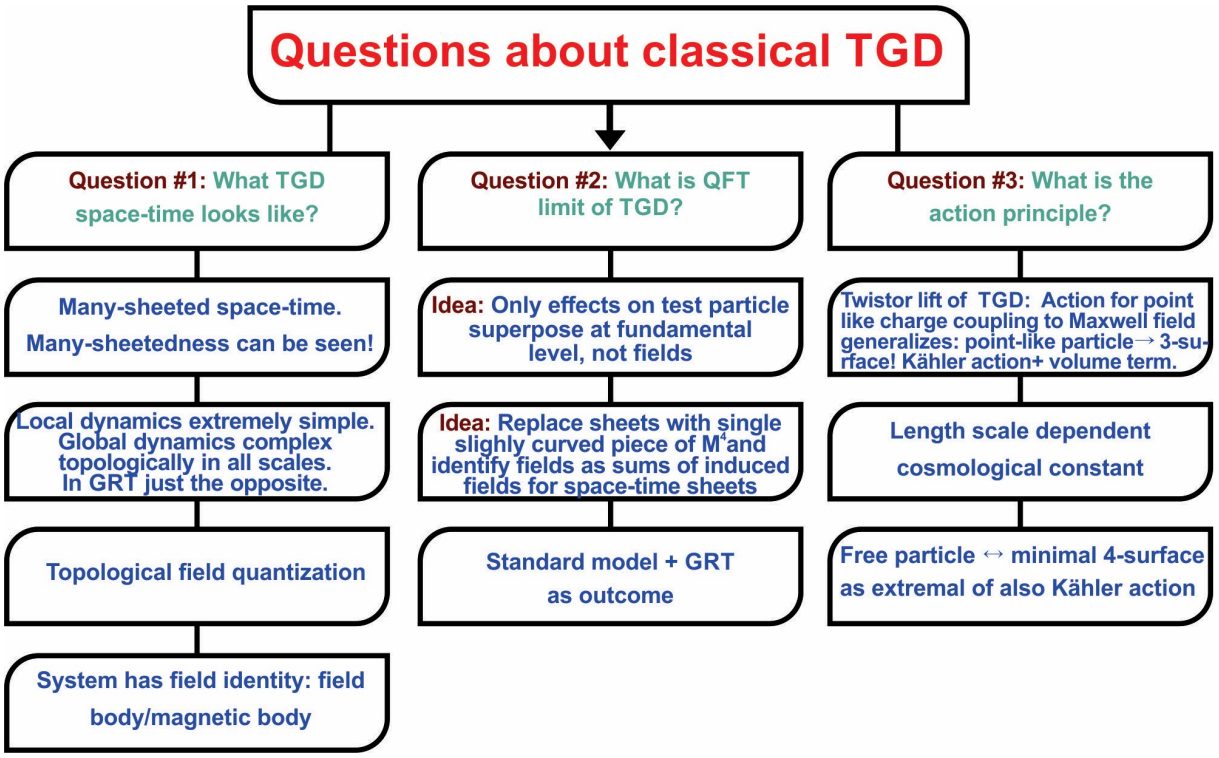

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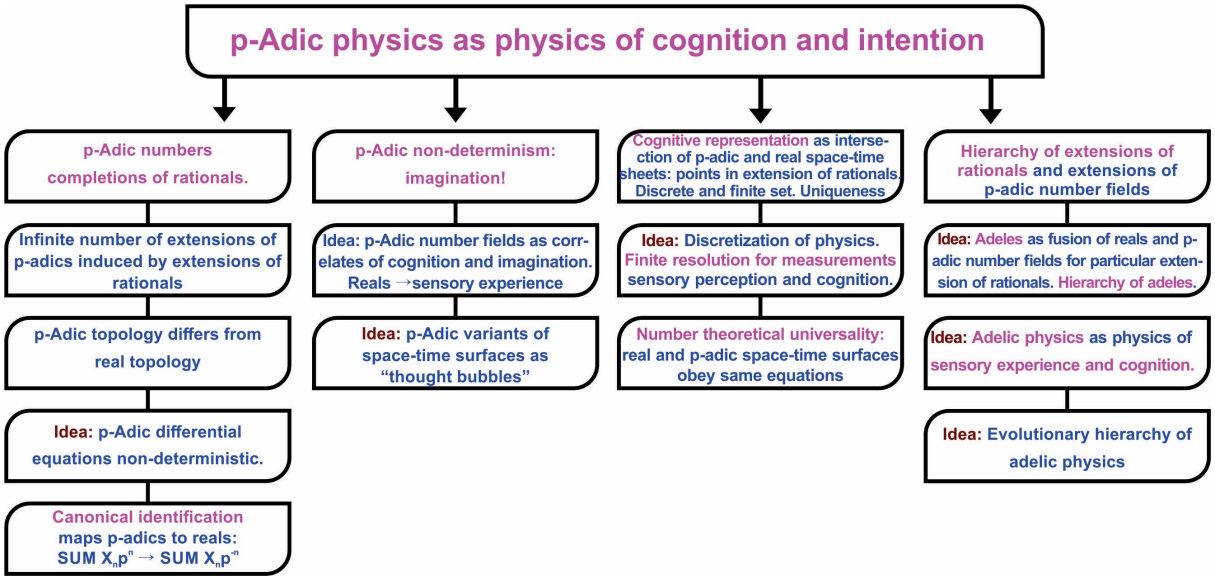

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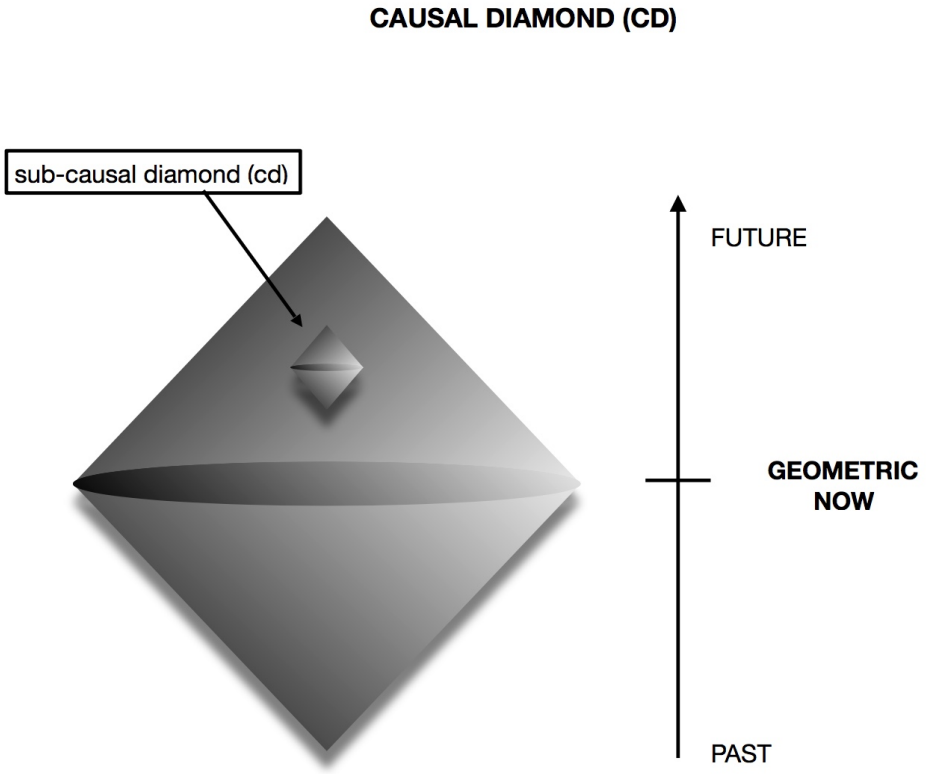
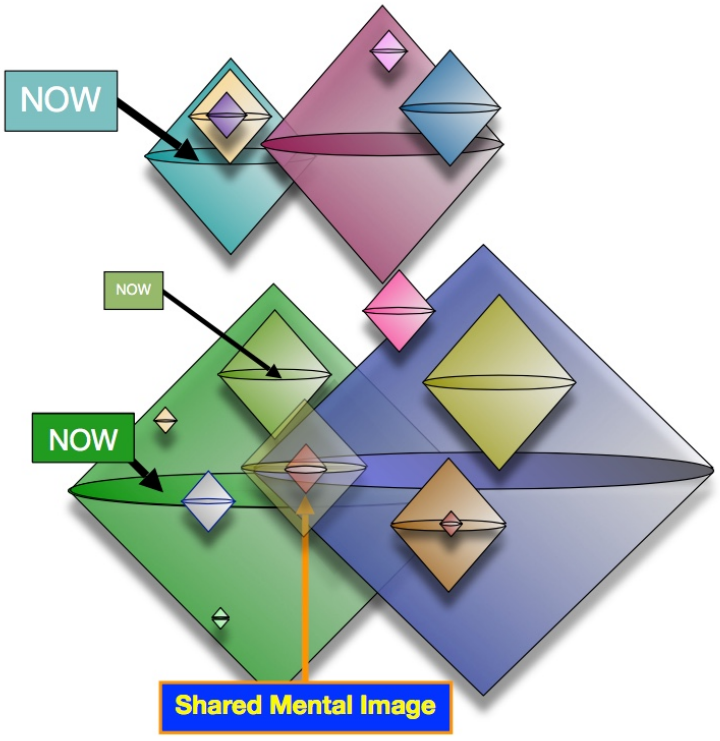


Figure 20: Causal diamond



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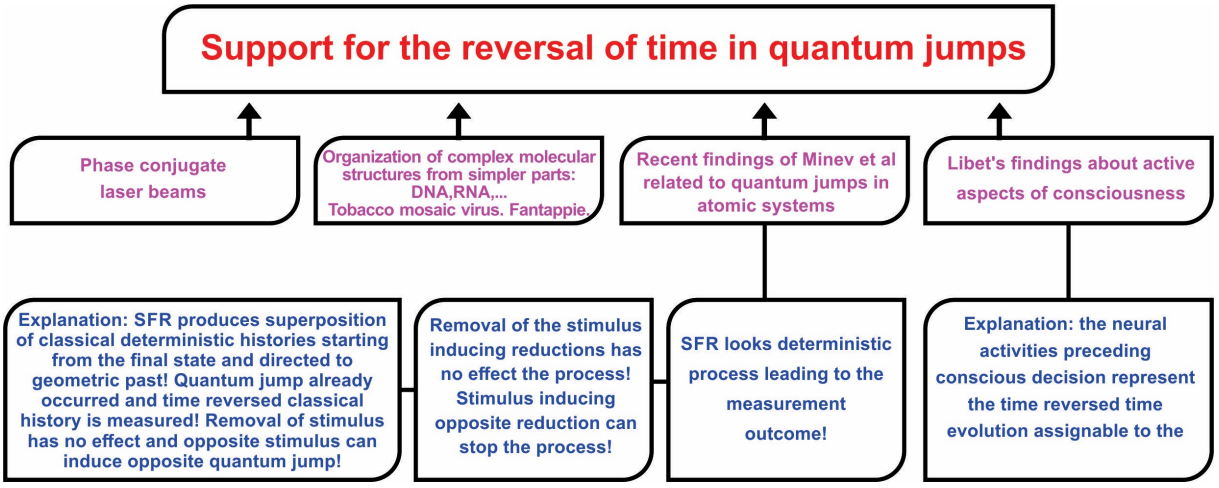

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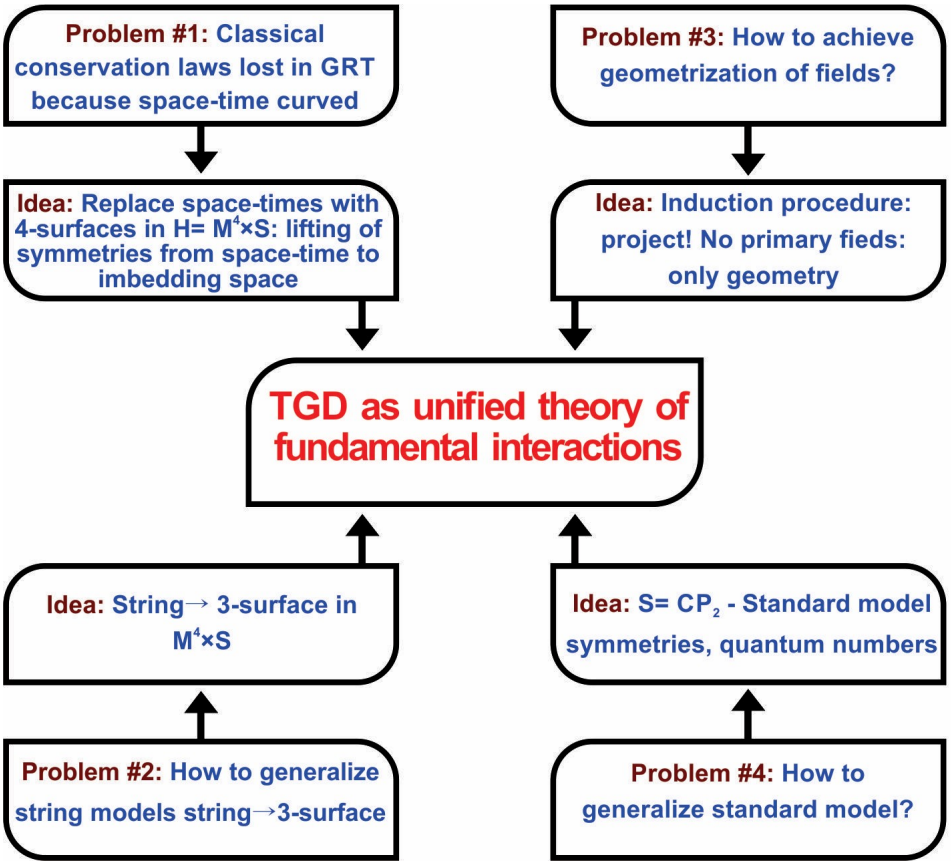

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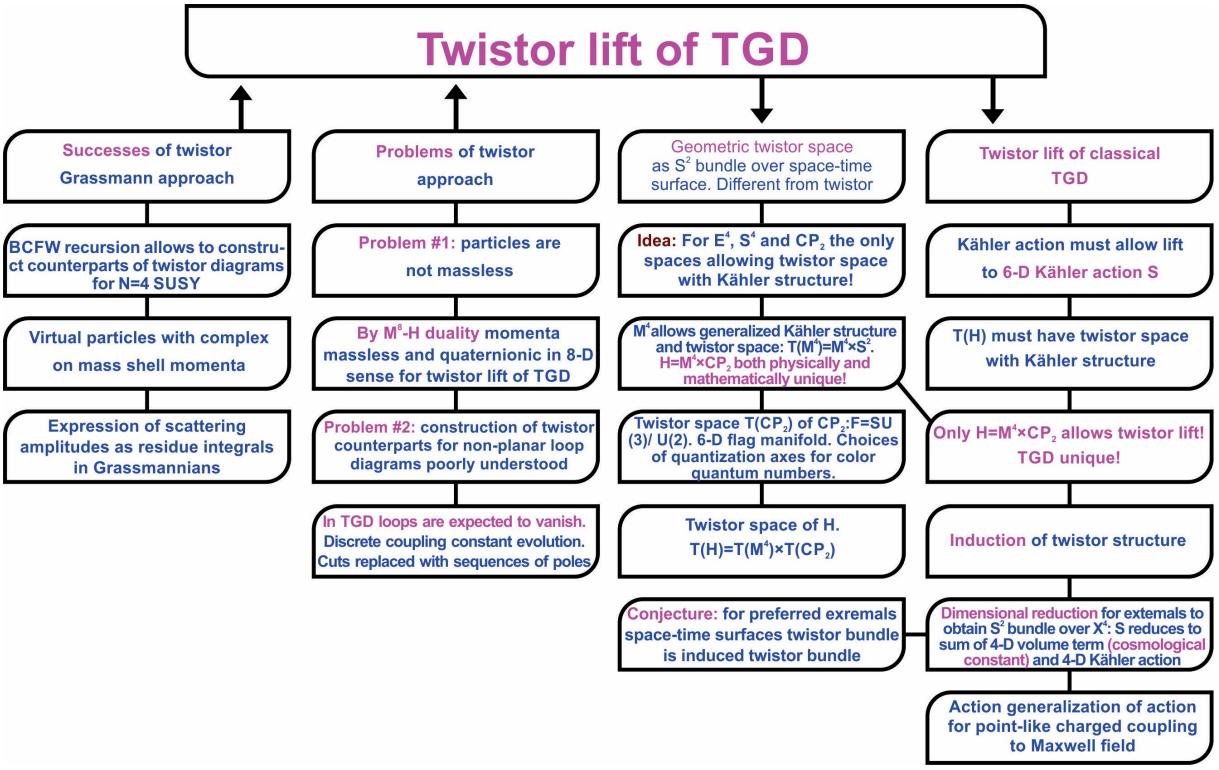

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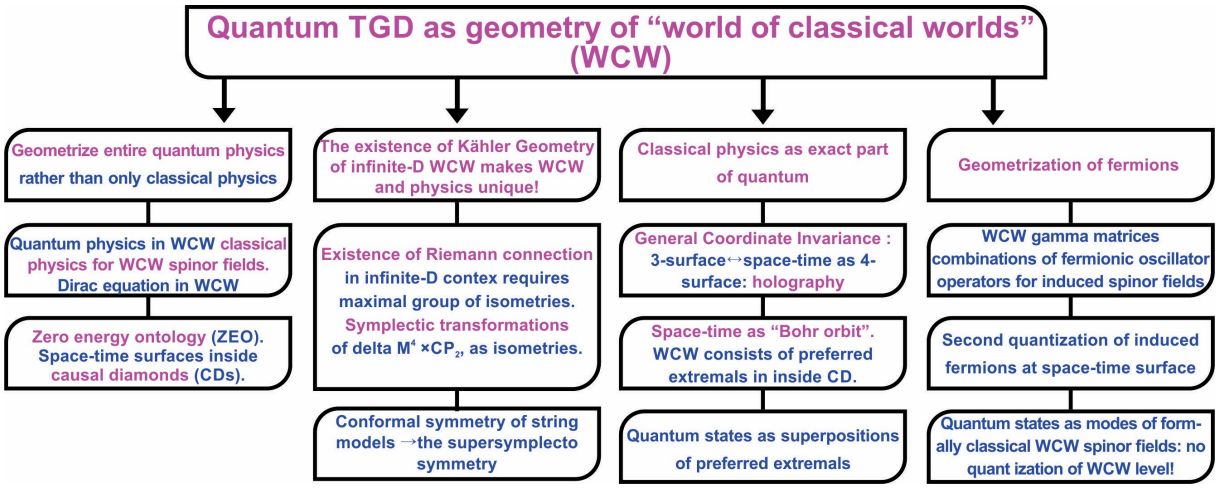

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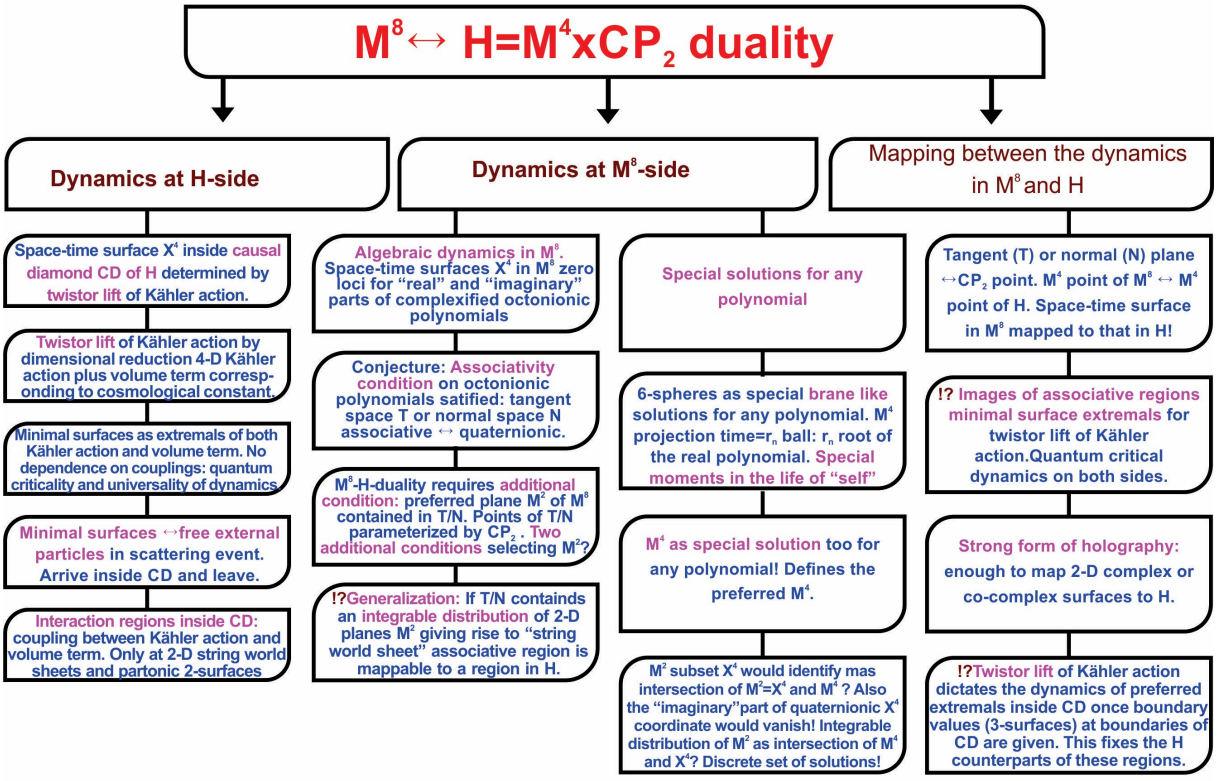
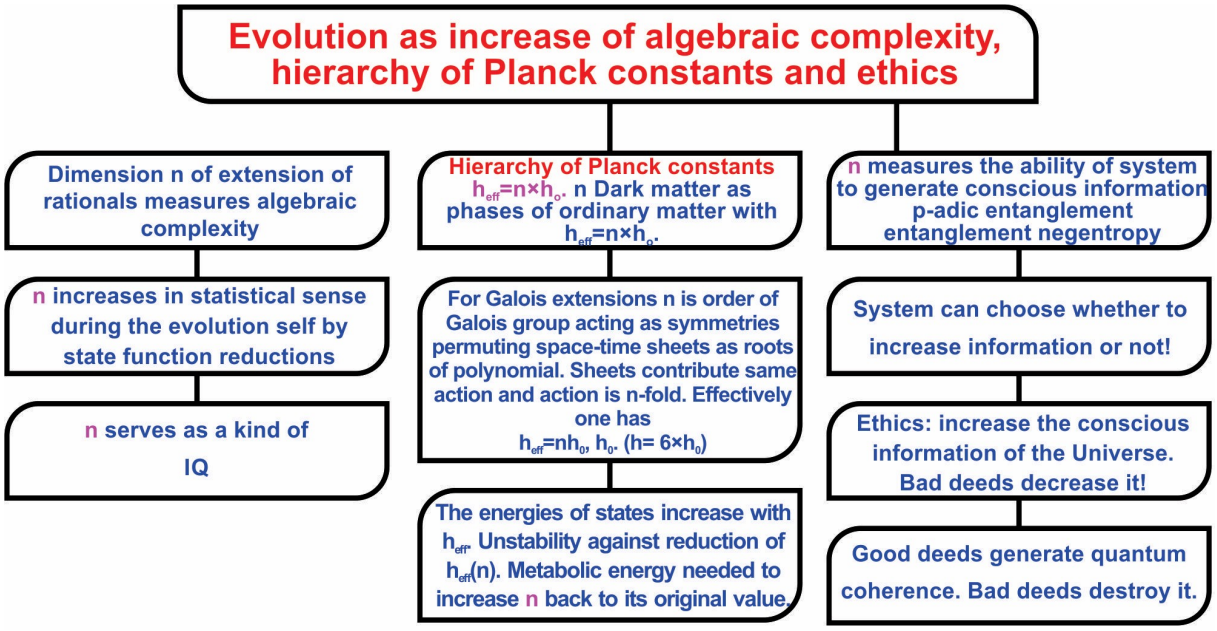


Figure 26: $M^8 - H$ duality



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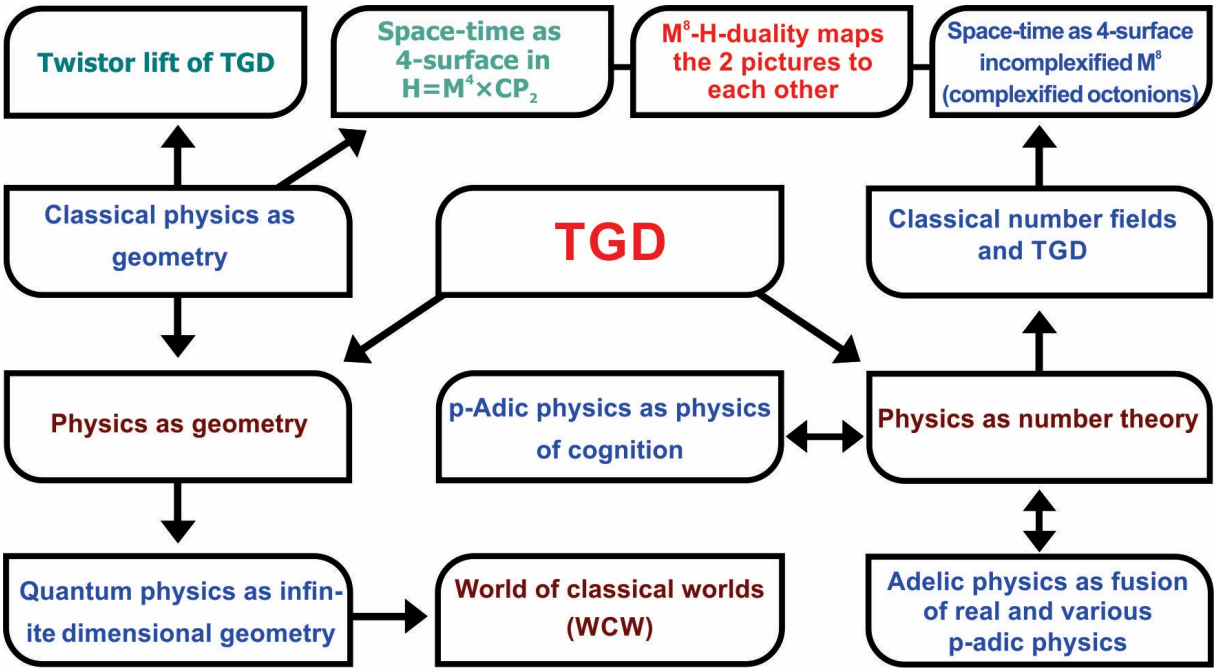

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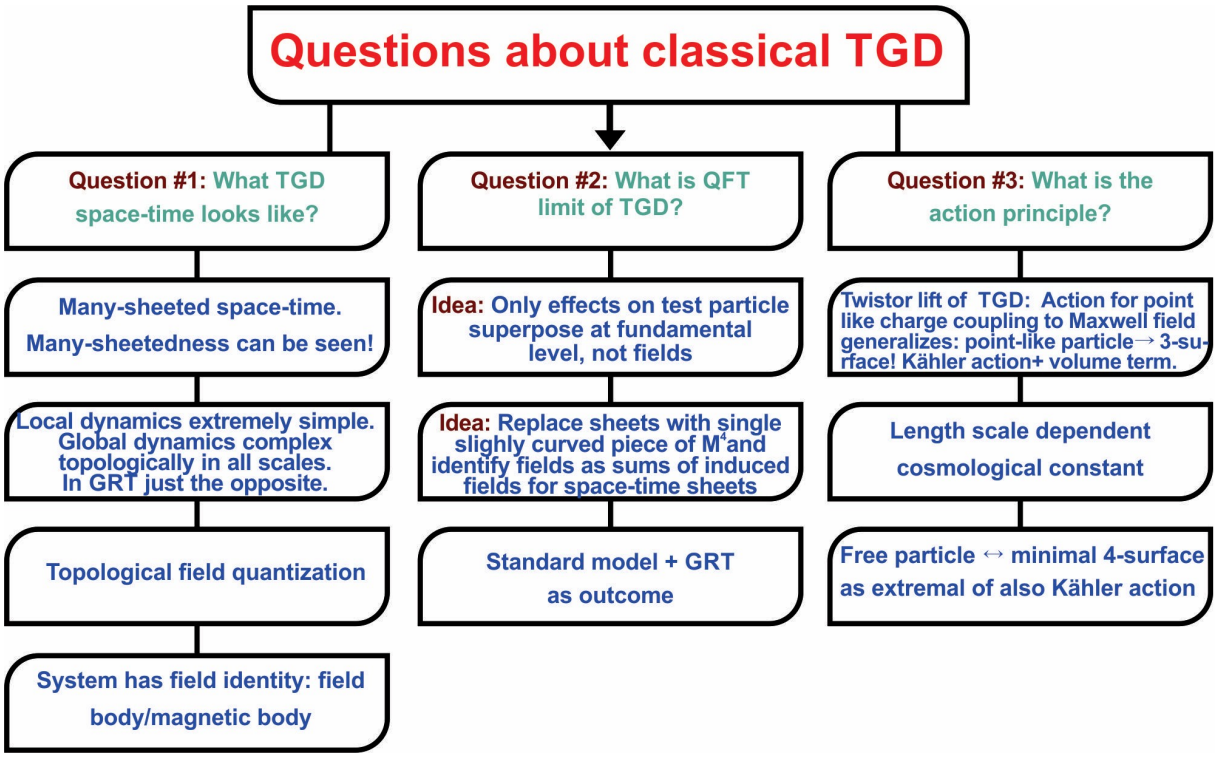

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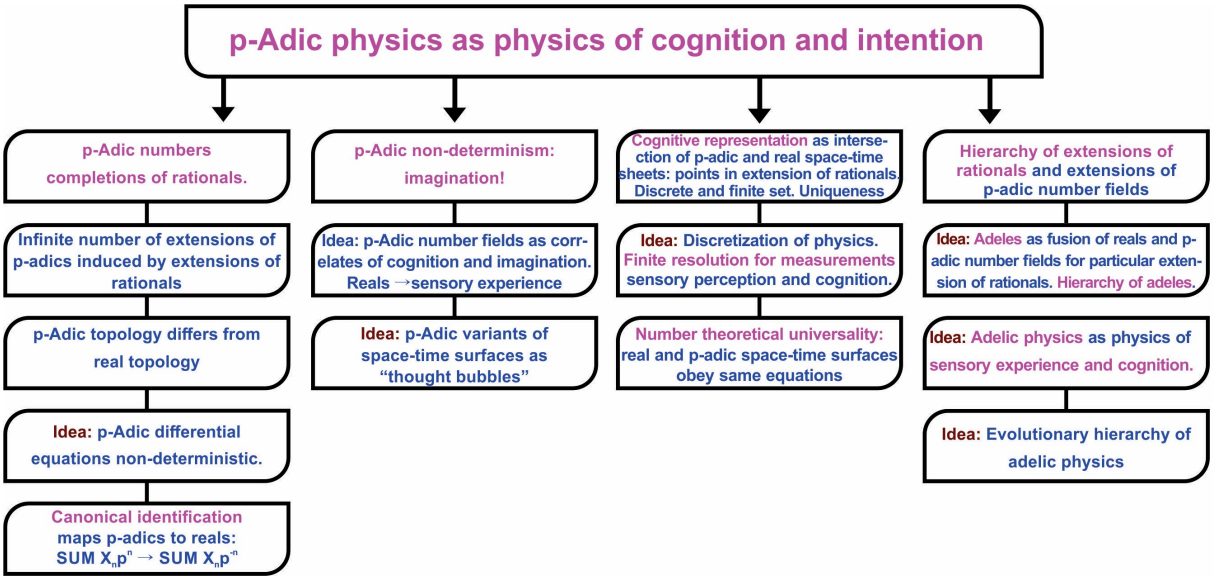

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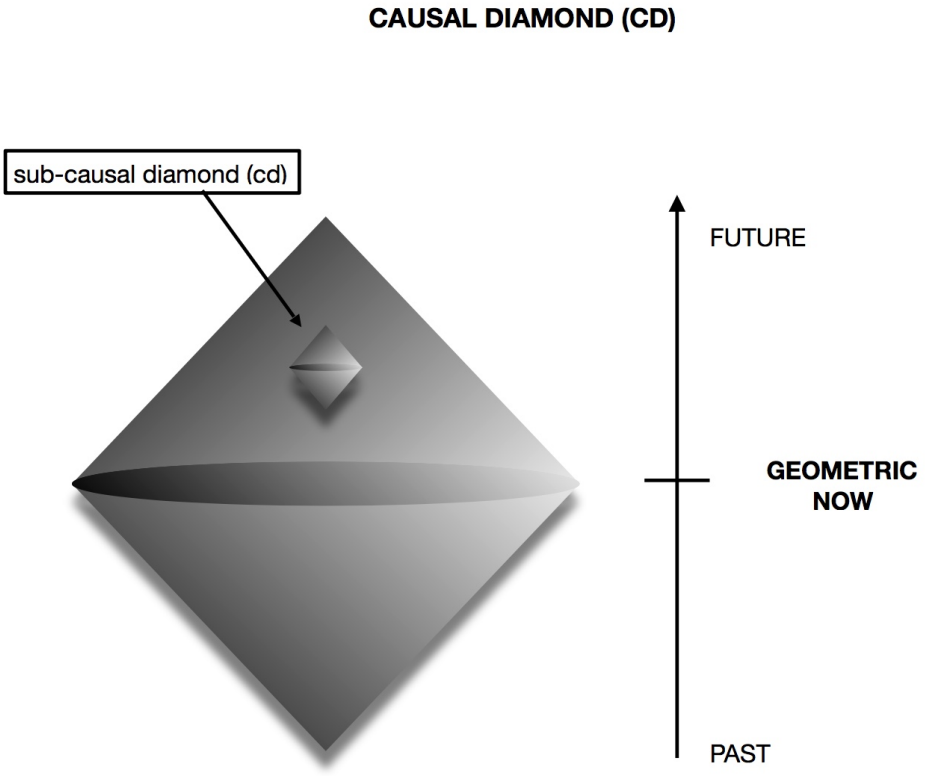

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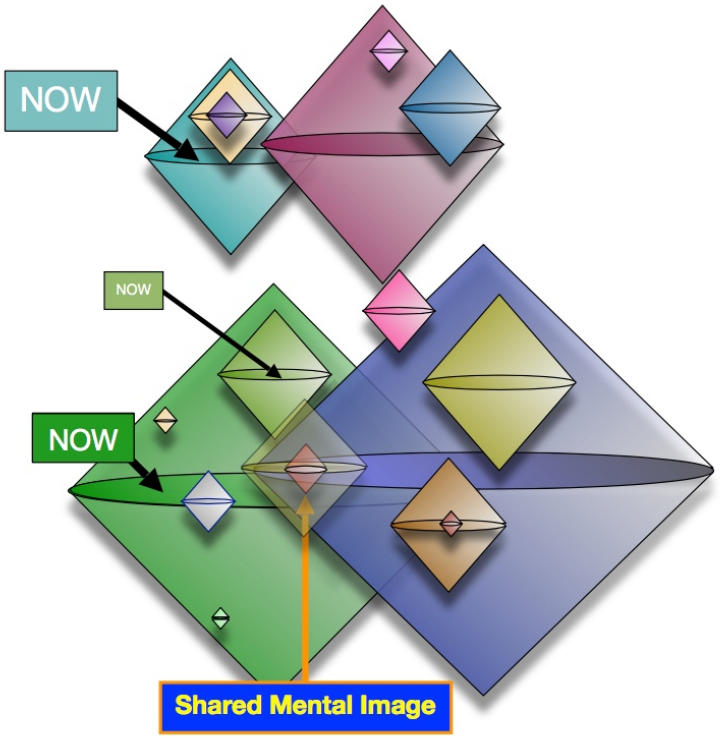

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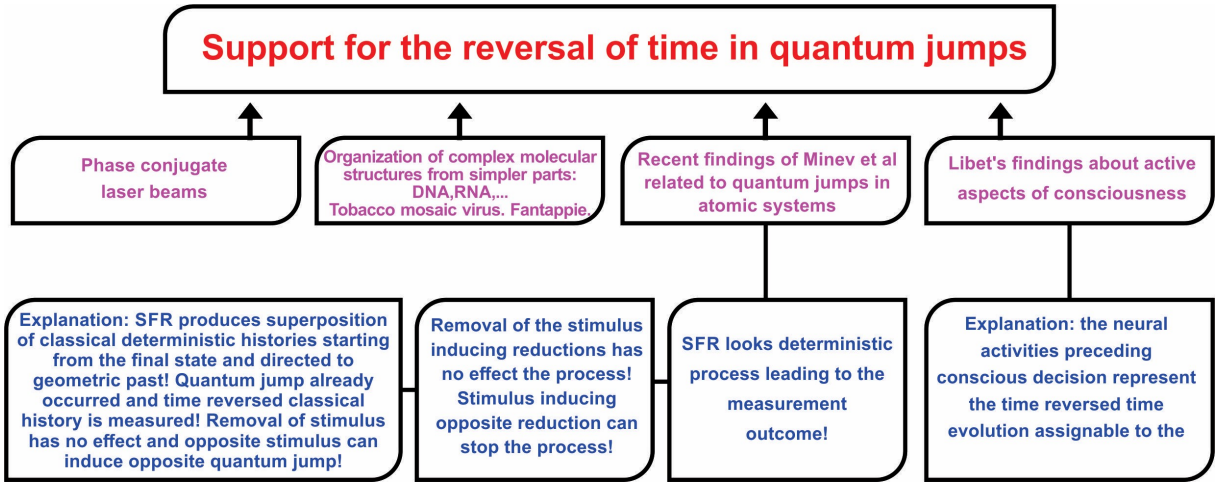

Figure 33: Time reversal occurs in BSFR

ACKNOWLEDGEMENTS

Neither TGD nor these books would exist without the help and encouragement of many people. The friendship with Heikki and Raija Haila and their family and Kalevi and Ritva Tikkanen and their family have been kept me in contact with the everyday world and without this friendship I would not have survived through these lonely 45 lonely years most of which I have remained unemployed as a scientific dissident. I am happy that my children have understood my difficult position and like my friends have believed that what I am doing is something valuable although I have not received any official recognition for it.

During the last decade Tapio Tammi has helped me quite concretely by providing the necessary computer facilities and being one of the few persons in Finland with whom to discuss my work. Pertti Kärkkäinen is my old physicist friend and has provided continued economic support for a long time. I have also had stimulating discussions with Samuli Penttinen who has also helped to get through the economical situations in which there seemed to be no hope. The continual updating of fifteen online books means quite a heavy bureaucracy at the level of bits and without a systemization one ends up with endless copying and pasting and internal consistency is soon lost. Tommi Ullgren has provided both economic support and encouragement during years. Pekka Rapinoja has offered his help in this respect and I am especially grateful to him for my Python skills.

During the last five years I have had inspiring discussions with many people in Finland interested in TGD. We have had video discussions with Sini Kunnas and had podcast discussions with Marko Manninen related to the TGD based view of physics and consciousness. Marko has also helped in the practical issues related to computers and quite recently he has done a lot of testing of chatGPT helping me to get an overall view of what it is. The discussions in a Zoom group involving Marko Manninen, Tuomas Sorakivi and Rode Majakka have given me the valuable opportunity to clarify my thoughts.

The collaboration with Lian Sidorov was extremely fruitful and she also helped me to survive economically through the hardest years. The participation in CASYS conferences in Liege has been an important window to the academic world and I am grateful for Daniel Dubois and Peter Marcer for making this participation possible. The discussions and collaboration with Eduardo de Luna and Istvan Dienes stimulated the hope that the communication of new vision might not be a mission impossible after all. Also blog discussions have been very useful. During these years I have received innumerable email contacts from people around the world. I am grateful to Mark McWilliams, Paul Kirsch, Gary Ehlenberg, and Ulla Matfolk and many others for providing links to possibly interesting websites and articles. We have collaborated with Peter Gariaev and Reza Rastmanesh. These contacts have helped me to avoid the depressive feeling of being some kind of Don Quixote of Science and helped me to widen my views: I am grateful for all these people.

In the situation in which the conventional scientific communication channels are strictly closed it is important to have some loop hole through which the information about the work done can at least in principle leak to the public through the iron wall of academic censorship. Without any exaggeration I can say that without the world wide web I would not have survived as a scientist nor as an individual. Homepage and blog are however not enough since only the formally published result is a result in recent day science. Publishing is however impossible without direct support from power holders- even in archives like arXiv.org.

Situation changed as Andrew Adamatsky proposed the writing of a book about TGD when I had already gotten used to the thought that my work would not be published during my lifetime. The Prespacetime Journal and two other journals related to quantum biology and consciousness - all of them founded by Huping Hu - have provided this kind of loophole. In particular, Dainis Zeps,

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 [K1].

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 [A15]. 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 nonvanishing 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 [A6] [B10, B8, B9]), 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 [B7]) 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 [A11, A14, A8, A13].

The identification of the space-time as a sub-manifold [A12, A17] 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.

[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 [A16, A18, A20]. 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 [K65]. 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 [K61].

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 $Y^4 \subset M^8_c$, where M^8_c 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^8_c, equivalently E^8_c, can be regarded as complexified octonions. M^8_c has a subspace M^4_c 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^8_c.

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 $Re(E)^2$.

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

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 $SU(3) \to CP_2$ 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 $M^4_c \subset M^8_c$ 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^3_i 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^3_i 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 $1 \oplus 3 \oplus \overline{3}$. The automorphism property requires that 1 can be transformed to 3 or $\overline{3}$ to themselves: this requires that the decomposition contains $3 \oplus \overline{3}$. Furthermore, it must be possible to transform 3 and $\overline{3}$ to themselves, which requires the presence of 8. This leaves only the decomposition $8 \oplus 3 \oplus \overline{3}$. 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 [K91].

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 [K76, K77, K74]) 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 [K104]. 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 [A15]. 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 [L53].

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 [L39]. 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 "TGD and EEG: Part I"

The TGD based general view about EEG developed in this book relies on the following general picture.

1. TGD Universe is fractal containing fractal copies of standard model physics at various space-time sheets and labeled by the collection of p-adic primes assignable to elementary particles and by the level of dark matter hierarchy characterized partially by the value of Planck constant labeling the pages of the book like structure formed by singular covering spaces of the embedding space $M^4 \times CP_2$ glued together along a four-dimensional back. Particles at different pages are dark relative to each other since purely local interactions defined in terms of the vertices of Feynman diagram involve only particles at the same page. Fractality includes also a hierarchy of conscious entities-selves- and also moment of consciousness identified as quantum jump has fractal structure.

2. A central notion is that of magnetic body. Magnetic body acts as an intentional agent using biological body as a motor instrument and sensory receptor. There is an entire hierarchy of magnetic bodies associated with various body parts and characterized by the respective p-adic length scale $L_p = L(k)$, $p \simeq 2^k$, and the level of dark matter hierarchy labeled by rational number characterizing the value of Planck constant involved. There are indications

that the values of Planck constant given by $\hbar = 2^{11k_d}\hbar_0$ are favored in living matter. The values of p and $\hbar/\hbar_0$ could be seen as kind of intelligence and spiritual quotients.

3. Magnetic body controls the biological body and receives information from it. The hierarchy of EEGs (more generally the counterparts of EEG associated with Z^0, and W bosons and gluons) consisting of dark bosons with energies above thermal threshold by the large value of $\hbar$, is the central aspect of this activity.

4. Cyclotron radiation assignable to cyclotron Bose-Einstein condensates at magnetic body and Josephson radiation assignable to Josephson junctions associated with the cell membrane and other electret type structures abundant in living matter are in a dominant role concerning communication and control. In particular, Cyclotron and Josephson frequencies correspond to EEG frequencies which together with p-adic length scale hypothesis leads to a highly predictive scenario.

5. The vision about DNA as topological quantum computer leads to a rather detailed view about how genome and cell membrane interact. Nucleotides and lipids would be connected by magnetic flux tubes carrying dark matter with varying values of Planck constant and define braiding affected by the 2-D flow of the lipids in liquid crystal state and giving rise to a topological quantum computation with program modules defined by standard liquid flow patterns resulting via quantum self organization process in presence of metabolic energy feed.

6. Sensory qualia could be associated with the generalized di-electric breakdowns between sensory organ and its magnetic body behaving somewhat like a capacitor. The cyclotron phase transitions of Bose-Einstein condensates of biologically important ions generated by the dark EEG photons at the magnetic body generate magnetic somatosensory qualia identifiable as our cognitive and emotional qualia. Long ranged charge entanglement made possible by W MEs (topological light rays) are essential element of all motor control and generate exotic ionization of nuclei (new nuclear physics predicted by TGD) in turn inducing classical electric fields at space-time sheets carrying ordinary matter. These fields generate various responses such as ionic waves and nerve pulses yielding the desired physiological responses.

1.2.1 Topics of "TGD and EEG: Part I"

The book contains 2 parts.

1. In the first part TGD inspired quantum neuroscience is discussed at a general level. A general vision of Quantum Mind in neuroscience is considered. The remaining chapters discuss several topics: the idea that emotions could be regarded as sensory perceptions about the state of the magnetic body (MB); the TGD view of neutron; the possible role of dark valence electrons in color vision; and the role of biophotons in brain function based on experimental work done by Michael Persinger's group.

2. The second part contains chapters representing models for EEG and nerve pulse based on the notion of dark matter hierarchy realized at the hierarchy of magnetic bodies with the Earth's and even Sun's magnetic bodies being in an important role. Gravitational quantum coherence on astrophysical scales would be essential.

   The model of cell membrane as a collection of Josephson junctions assignable to membrane proteins and allowing idelization as a single Josephson junction. Dark Josephson currents would generate dark Josephson radiation received by the magnetic body and generate a sequence of resonance pulses which would code the oscillations of the membrane potential to sequences of pulses, maybe nerve pulses. The connection of EEG band structure and structure of the magnetic body of Earth is considered. A model for the nerve pulse is considered.

1.3 Sources

The eight online books about TGD [K110, K105, K82, K69, K21, K66, K50, K94] and nine online books about TGD inspired theory of consciousness and quantum biology [K102, K17, K73, K15,

K46, K56, K59, K93, K101] 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: QUANTUM NEUROSCIENCE IN TGD UNIVERSE

Quantum Mind and Neuro Science

The article discusse some applications of TGD inspired view about Quantum Mind to neuroscience. Magnetic body carrying dark matter and forming an onionlike structure with layers characterized by large values of Planck constant is the key concept.

A general model for qualia is introduced. The identification of the correlates of the fundamental qualia as quantum number increments for a subsystem is in a complete analogy with the identification of quantum numbers as characterizers of physical states. A general classification of qualia based on thermodynamical notions is discussed and a mechanism generating sensory qualia is proposed. Also the question whether some qualia could correspond also to those of magnetic body is raised.

The interaction of subsystem S representing self with environment E is assumed to generate a negentropic entanglement between S and environment E. As long as this negentropic entanglement lasts, qualia are experienced. After the state function reduction eliminating this entanglement, there can be only a memory of qualia. There is clearly a resemblance with Orch OR of Penrose and Hameroff. During negentropic entanglement there is polarization in scale of $S \otimes E$ and S and E carry opposite quantum numbers. After the state function reduction negentropic entanglement and polarization prevail only in the scale S and S has vanishing net quantum numbers. "Quantum number increments ΔQ in quantum jump" therefore correspond to the reduction of charges of subsystem in the state function reduction process. The system is analogous to a capacitor whose size scale is that of $S \otimes E$ during the sensation of quale and that of S after it. In ZEO one can consider states of S at both upper and lower boundaries of CD and assign ΔQ with this time evolution so that quantum classical correspondence is realized.

The capacitor model for sensory receptor based on the idea that sensory qualia are generated in the analog of di-electric breakdown introducing a flow of large number of particles with quantum numbers characterizing the quale. A model for the cell membrane as sensory receptor and as qualia chart with lipids serving as its pixels is developed. Although sensory organs are assumed to define the seats if the fundamental qualia, also neurons would define sensory homunculi not necessarily responsible for sensory mental images at our level of self hierarchy. Cell membrane is assumed to be a quantum critical system taken to mean that it is near to a vacuum extremal of so called Kähler action. This explains large parity breaking in living matter (chiral selection) very difficult to understand in standard model. The model explains the peak frequencies of visible light for photoreceptors and predicts that bio-photons and bunches of EEG photons result as decay products of same dark photons with energies mostly in visible range.

Few years after the writing of the first version of this chapter a progress in the understanding of self. Self can be identified as a sequence of quantum jumps as originally proposed but assuming that the quantum jump sequence correspond to a repeated state function reduction at the same boundary of CD. In ordinary quantum measurement theory repeated reduction would not change the state at all. This also the case for the second boundary of CD., say positive energy boundary. Now the parts of zero energy states associated with the negative energy boundary change. Besides this one has a wave function in the moduli space of the second boundary. Moduli include also the temporal distance between the tips of CD. The statistical increase of this distance gives rise to the flow and arrow of psychological time and self can be identified as the sequence of quantum jumps

giving rise to a state function reduction at the same boundary of CD. The capacitor discharge correponds to a sequence of state function reductions to a fixed boundary of CD.

The model of nerve pulse relies on the hypothesis that axonal membrane defines a Josephson junction. The ground state of the axon corresponds to a propagating soliton sequence for the phase difference over the membrane mathematically analogous to a sequence of coupled gravitational penduli with a constant phase difference between neighboring penduli. Nerve pulse is generated as one kicks one of the oscillating penduli. The model of nerve pulse explains the generation of EEG. The resonance frequencies of EEG can be understood as sums and differences of the harmonics of cyclotron frequencies of biologically important dark ions and of Josephson frequency.

A model of bio-photons is discussed. The motivation comes from the observations that bio-photons could be interpreted as decay products of large $\hbar$ EEG photons resulting in the energy conserving transformation to ordinary photons at visible and UV energies.

Emotions as sensory percepts about the state of magnetic body?

What emotions are? How emotions are created? How they are represented: in brains, at body, or somewhere else? Emotions can be divided into lower level emotions and higher level emotions. What does does this correspond to?

1. TGD inspired answer to the questions is that emotions are sensory percepts about the state of magnetic body (MB). Sensory-motor loop generalizes: various glands excreting hormones to blood stream and binding to receptors give rise to the analog of motor output.

2. Neural transmitters binding to receptors serve as bridges allowing to build connected networks of neurons from existing building bricks. They are accompanied by flux tube networks giving rise to tensor networks as quantum coherent entangled structures serving as correlates of mental images and allowing classical signalling with light velocity using dark photons.

   In a similar manner hormones give rise to networks of ordinary cells implying in particular that emotional memories are realized in (biological) body (BB). Nervous system gives information about the state of these networks to brain. Hypothalamus serves as the analog of motor cortex excreting hormones controlling the excretion of hormones at lower level glands.

3. The hierarchy of Planck constants defines a hierarchy of dark matters and $h_{eff} = n\times$ defines a kind of IQ. The levels of MB corresponding to large/small values of n would correspond to higher/lower emotions.

MB decomposes to two basic parts: the part in the scale of BB and formed by networks having cells and larger structures as nodes (forming a fractal hierarchy) and the part in the scales larger than BB.

1. In the scales of BB (short scales) the dynamics involves topological dynamics of the flux tube network and sensory percepts can be accompanied by conscious-to-us desire to change the state of MB and thus of BB and could be seen as intentions induced by the comparison between what happened and what were the expectations. The outcome would be state function reduction replacing the behavioral pattern with a new one giving better hopes for achieving the goal. In zero energy ontology (ZEO) behavioral pattern is represented as quantum superposition of 4-D MBs so that time aspect is naturally involved with emotions.

2. In the scales larger than that of BB (long scales) the change the topology is not easy and the dynamics involves oscillations of MB - analogs of Alfwen waves - and analogs of ordinary motor actions changing the shape of flux tubes but leaving its topology unaffected.

   Alfwen waves with cyclotron frequencies and generalized Josephson frequencies assignable to cell membrane as Josephson junction would be involved. The size scale of particular onyon-like layer of MB corresponds to the wavelength scale for cyclotron frequencies and is proportional to $h_{eff}/h = n$ for dark photons. For instance, alpha band in EEG corresponds to the scale of Earth but the energy scale of dark photons is that of bio-photons.

   The TGD inspired model of music harmony gives as a side product a model of genetic code predicting correctly the numbers of codons coding for amino-acids for vertebrate code. The

model allows to see sensory percepts about the dynamics in large scales as analog of music experience. The notes of 3-chords of the harmony correspond to light as dark photons and frequencies defining the notes of the chord: cyclotron radiation and generalized Josephson radiation from cell membrane would represent examples of dark light. Music expresses and creates emotions and music harmonies would correspond to various emotional states/moods realized at the level of DNA and its dark counterpart (dark nuclei represented as dark proton sequences). MB would be like a music instrument with flux tubes serving as strings. It is difficult to assign any specific desire to large scale sensory percepts about MB and the interpretation as higher emotions - or rather feelings - makes sense.

About TGD based view of neuron

The realization that saltation as a conduction over the myelinated portions of the axon is still poorly understood phenomenon inspired a careful reanalysis of the earlier TGD inspired visions of nerve pulse conduction, EEG and of brain based on the new view about space-time, the notion of the magnetic body carrying $h_{eff} > h$ phases behaving like dark matter, and the zero energy ontology (ZEO) based quantum measurement theory extending to a theory of consciousness.

The TGD view about nerve pulse replaces nerve pulse as a wave assignable to a generalized Josephson junction formed by lipid layers of the cell membrane for which Josephson frequency f_J is replaced by the sum $F_J = f_J + \Delta f_c$, where Δf_c is the difference between cyclotron frequencies for transversal flux tubes at the different sides of the axon. What propagates is the deviation of membrane potential below the critical value for the generation of action potential. There would be no action potential in the myelinated portions of the axon and it would be generated only in the non-myelinated portions of length about 1 μm and gives rise to chemical effects and also communicate a signal to the magnetic body if the notion of generalized Josephson junction is accepted.

An interesting challenge for the model is the discovery that the density of the voltage gated ionic channels in the dendrites of neurons is considerably lower for humans than for mammals. The general model suggests that the spatiotemporal patterns of Josephson radiation emitted by segments between nearby ionic channels or pumps define analogs of sentences of language having nerve pulse as a punctuation mark analogous to the stop codon for DNA, then these sentences would be longer for humans, which could relate to the emergence of the human language capacity.

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.

Comments about the recent experiments by the group of Michael Persinger

Michael Persinger's group reports three very interesting experimental findings related to EEG, magnetic fields, photon emissions from brain, and macroscopic quantum coherence. The findings also provide support for the proposal of Hu and Wu that nerve pulse activity could induce spin flips of spin networks assignable to cell membrane. In this article I analyze the experiments from TGD point of view. It turns out that the experiments provide support for several TGD inspired ideas about living matter - namely, magnetic flux quanta as generators of macroscopic quantum entanglement, dark matter as a hierarchy of macroscopic quantum phases with large effective Planck constant, DNA-cell membrane system as a topological quantum computer with nucleotides and lipids connected by magnetic flux tubes with ends assignable to phosphate containing molecules,

and the proposal that "dark" nuclei consisting of dark proton strings could provide a representation of the genetic code. The proposal of Hu and Wu translates into the assumption that lipids of the two layers of the cell membrane are accompanied by dark protons which arrange themselves to dark protonic strings defining a dark analog of DNA double strand.

1.3.2 PART II: QUANTUM MODEL FOR EEG AND NERVE PULSE

Dark Matter Hierarchy and Hierarchy of EEGs

The emergence of zero energy ontology, the explanation of dark matter in terms of a hierachy of Planck constants requiring a generalization of the notion of embedding space, the view about life as something in the intersection of real and p-adic worlds, and the notion of number theoretic entanglement negentropy led to a breakthrough in TGD inspired quantum biology and also to the recent view of qualia and sensory representations including hearing allowing a precise quantitative model at the level of cell membrane.

Also long range weak forces play a key role. 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 standard ground state classical Z^0 fields are very weak. This leads to a correct prediction for the frequencies of peak sensitivity for photoreceptors - something highly non-trivial remembering that also the large parity breaking effects in living matter find a natural explanation. It must be however emphasizef that there is also alternative model of Josephson junctions which seems to provide a better explanation for the role of protons in metabolism. Second quantitative key observation was that for electrons and quarks the time scales of causal diamonds correspond to fundamental biorhythms assignable to central nervous system.

The general model for EEG follows neatly from this picture combined with the general model of high T_c superconductivity. A fractal hierarchy of EEGs and its generalizations identified in terms of Josephson radiation is predicted with levels labeled by p-adic length scales and the value of $\hbar$ at various levels of dark matter hierarchy. Cell membrane would represent only one level in this hierarchy. Besides EEG one would have its counterparts for various organs, organelles and even cell. Also the possibility of ZEG, WEG and QEG corresponding to Z^0 bosons, W bosons, and gluons must be considered.

1. Fractal hierarchy of EEGs

EEG is replaced with a fractal hierarchy of EEGs corresponding to various values of Planck constants involved.

1. There are at least three contributions to EEG besides the contributions due to the neural noise and evoked potentials. These contributions correspond to Schumann frequencies, cyclotron frequencies f_c of biologically important ions in magnetic field $B_{end} = .2$ Gauss, and to the Josephson frequencies f_J or theire generalizations associated with Josephson junctions assigned with cell membranes. If Josephson radiation modulates cyclogtron radiation also the frqequencies $mf_J \pm nf_c$ appear in the spectrum. Perhaps the most natural option is generalization of Josephson junction so that generalized Josephson frequencies are sums for differences of cyclotron frequencies for flux tubes in the interior resp. exterior of cell membrane and of Josephson frequency f_J . This implies that the information provided by cell membrane oscillations and nerve pulse patterns is coded to frequency modulations for differences of cyclotron frequencies defining EEG rhythms.

2. In standard model $f_J = ZeV/\hbar$ would determined by the membrane potential and would correspond to energy in infrared. This sounds completely reasonable. TGD suggests two models for the cell membrane.

3. TGD inspires two views about cell membrane: the wiews need not be contradictory. For the first model cell is far from vacuum extremal, for the second model nearly vacuum extremal with classical Z^0 fields in key role.

   (a) There are several constraints on the first model coming from the TGD based identification of bio-photons as energy conserving decay products of dark photons and one

ends up to a new view about metabolism and gneralization to of the notion of Josephson junction so that Josephson energy includes besides electrostatic energy also the difference of cyclotron energies at two sides of the membrane. 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.

(b) It has been clear from the beginning that the nearly vacuum extremals of Kähler action could play key role key role in living systems. The reason is their criticality making them ideal systems for sensory perception. These extremals carry classical em and Z^0 fields related to each other by a constant factor and this could explain the large parity breaking effects characterizing living matter. The assumption that at least some cell membranes are nearly vacuum extremals and that nuclei can feed their Z^0 charges to this kind of space-time sheets (not true for atomic electrons) in living matter leads to a modification of the model for the cell membrane as Josephson junction. Also a model of photoreceptors explaining the frequencies of peak sensitivity as ionic Josephson frequencies and allowing the dual identifications Josephson radiation as biophotons (energies) and EEG radiation (frequencies) emerge since the values of Planck constant can be very large. Contrary to the original believe, this model does not require non-standard value of Weinberg angle and this model and first model allow a hybrid.

4. An important point is that the ions involved must behave like bosons or to form Cooper pairs. For cyclotron condensates either Cooper pairs of ordinary fermionic ions or exotic ions chemically similar to their standard counterparts obtained from neutral bosonic atom by making one or more neutral color flux tubes connecting nucleons charged. For Josephson radiation only the latter option works. TGD based nuclear physics indeed predicts this kind of nuclei and there is experimental evidence for their existence.

5. For cyclotron frequencies the extremals are assumed to be far from vacuum extremals carrying very small classical Z^0 fields but nonvanishing classical W fields and color fields (with $U(1)$ holonomy). The corresponding flux quanta would naturally correspond to flux sheets traversing through DNA strands while Josephson radiation would propagate along flux tubes parallel to the cell membrane. Far from biological body one expects both kinds of flux quanta to fuse to form larger ones so that one has parallel space-time sheets carrying cyclotron *resp.* Josephson radiation. Wormhole contacts between Josephson and cyclotron flux sheets would induce a non-linear interaction giving rise to a superposition of harmonics of Josephson and cyclotron frequencies.

6. Josephson frequencies are assignable to the cell membrane and would naturally correspond to the communication of sensory data to the magnetic body. This would suggest that cyclotron frequencies are assignable to the magnetic flux sheets going through DNA strands responsible for quantum control via genome expression. This picture might be too naive. Josephson radiation would induce transitions between cyclotron states should generate sensory representations at magnetic body so that both frequencies would be involved with sensory representations. Furthermore, the identification of motor action as time reversal of sensory perception allwed by zero energy ontology would mean that same mechanisms are at work for negative energies (phase conjugate radiation). Resonance is achieved if the condition $mf_J = nf_c$ is satisfied. For small values of integers m and n the condition is quite restrictive. Schumann frequencies can be assigned with the magnetic body of Earth and would correlate with the collective aspects of consciousness.

7. The model of hearing forces to assume quite a wide spectrum of Planck constants- at least the values coming as powers of two and the safest assumption is that at least integer multiples of the ordinary Planck constant are possible. Josephson radiation and cyclotron radiation have same scale if $B_{end} \propto 1/\hbar$ proportionality holds true. For 5 Hz Josephson frequency and membrane potential and for V=.70 mV corresponding to the resting potential of neuron one obtains $r = (0.96, 1.20, 1.34, 1.01) \times 2^{47}$. For Ca^{++} ion r is very near to a power of 2.

2. Basic aspects of EEG

Consider now how one could understand basic characteristics of EEG during wake-up and sleep in this framework.

1. For small amplitudes and for the lowest harmonics this implies that alpha band to which the cyclotron frequencies most biologically important bosonic ions corresponds has as satellites theta and beta bands. Higher harmonics correspond to gamma and higher bands having also satellites.

2. For large amplitudes EEG becomes chaotic which is indeed the property of beta band during say intense concentration or anxiety. The findings of Nunez about narrow 1-2 Hz wide bands at 3,5,7 Hz and 13,15,17 Hz confirm with the prediction of satellite bands and fix the Josephson frequency to 5 Hz. This picture explains the general characteristics of EEG in wake-up state qualitatively and quantitatively.

3. In order to understand the characteristics during various stages of deep sleep one must assume that the cyclotron frequency scale of ions is scaled down by a factor of 1/2. The simplest explanation is that the value of Planck constant increases by a factor 2 in a phase transition having interpretation as a leakage of cell membrane space-time sheet between the pages of Big Book defined by the generalized embedding space. During stage 4 sleep only only DNA cyclotron frequencies in delta band are around 1 Hz and just above the thermal threshold are predicted to be present. This stage could correspond to a value of Planck constant which is 4 times its value in wake-up state.

The generalization of the model for EEG hierarchy to the case of ZEGs is straightforward and Josephson frequency spectrum is the same. Any atom, almost always boson, has an exotically charged counterpart with same statistics so that very rich spectrum of Bose-Einstein condensates results.

3. The effects of ELF em fields on brain

The experimental data about the effects of ELF em fields at cyclotron frequencies of various ions in Earth's magnetic field on vertebrate brains were crucial for the development of the model of EEG. As a matter fact, it was the attempt to explain these effects, which eventually led to the discovery of the fractal hierarchy of EEGs and its generalizations.

The reported effects occur for harmonics of cyclotron frequencies of biologically important ions in Earth's magnetic field. They occur only in amplitude windows. The first one is around 10^{-7} V/m and second corresponds to the range $1 - 10$ V/m: the amplitudes of EEG waves are in the range 5-10 V/m. The effects are present only in the temperature interval 36-37 C.

1. Cyclotron frequencies led to the vision about cyclotron condensates of biologically important ions and their Cooper pairs at the flux quanta of dark magnetic field with so large Planck constant that the energies of cyclotron photons are above thermal threshold. The model for EEG and biophotons in terms of Josephson radiation from cell membrane which is almost vacuum extremal allows to make this model more quantitative.

2. The temperature window has one interpretation in terms of a competion of almost vacuum extremal property of cell membrane possible above some critical temperature and high T_c super-conductivity possible below some critical temperature.

3. The amplitude window 10^{-7} V/mfollows from a quantized form of Faraday law whose existence is supported by the fact that space-time sheets are analogs of Bohr orbits in exact sene. The quantisation condition relates the amplitude of electric field to Planck constant and frequency. For the value $r = \hbar/\hbar_0 = 2^{47}$ of Planck constant required by 5 Hz Josephson frequency the 10^{-7} V/m amplitude is predicted correctly.

4. The amplitude window around 1-10 V/m (EEG amplitudes are in the range 5-10 V/m) follows if the values of Planck constant in the range $10^7 r - 10^8 r$ can be justified. A possible justification is based on the observation that for $r_1 = 10^8 r$ the Compton wave length of

intermediate gauge bosons corresponds to $k = 163$ defining Gaussian Mersenne and wavelength corresponding to 2 eV energy for photon which also corresponds to bio-photon energies assignable to 70 mV resting potential of neuron membrane. Electron's Compton length corresponds for $r_1 = 10^8 r$ to 28 cm, which defines the size scale of brain. One might hope that these findings could allow to build an internally consistent story about what happens.

4. Vision about biological evolution and evolution of brain

The proposed model for EEG, the idea that Gaussian Mersennes (four of them are in the range 10 nm-2.5 micrometers) define p-adic length scales allowing exotic variants of color and electro-weak physics with light intermediate gauge bosons at space-time sheets near vacuum extremals, and the assumption that the preferred values of Planck constant are such that they relate these p-adic scales to each other leads to a detailed quantitative vision about evolution of life as emergence of longer scales belonging to this hierarchy and as special case also to a vision about evolution of cell, nervous system, EEG, and long term memory. The model predicts a hierarchy of preferred size scales for various sub-systems of organisms and corresponding time scales identifiable in terms of bio-rhythms and memory span.

Quantum Model for EEG

In the previous chapter the overall TGD based view about EEG was discussed. According to this view, the basic function of EEG is to induce cyclotron phase transitions at the magnetic body and thus to produce what might be called higher level sensory qualia identified as emotions and cognitions. In this chapter the relationship between EEG and nerve pulse patterns is discussed in TGD framework.

The relationship between nerve pulse patterns and EEG (also ZEG) is one of the basic challenges of the theory. The question is whether nerve pulse patterns could give rise to EEG patterns and vice versa, and what could be the underlying mechanisms. The deep difference between TGD and the conventional neuroscience is the presence of the hierarchy of magnetic bodies, cyclotron transitions, and MEs. This makes possible to consider alternatives for the identification of EEG resonance frequencies as resonance frequencies of nerve circuits.

Nerve pulses generate EEG MEs and the frequency of the nerve pulses determines the rate at which EEG MEs are generated rather than the frequency of EEG MEs. Pendulum metaphor suggests how spike patterns amplify EEG waves at frequencies, which appear as resonances in the autocorrelation function of the spike sequence: when the pendulum is kicked at correct half of its period its oscillation frequency remains unchanged but amplitude and phase suffer discontinuous changes. The EEG waves generated by subsequent nerve pulses tend to interfere constructively resulting in amplification if the EEG frequency corresponds to a resonance frequency of the spike autocorrelation function.

1. Generalization of the model for sensory receptor and new view about hearing

The relationship between nerve pulse patterns and EEG (also ZEG) is one of the basic challenges of the theory. The question is whether nerve pulse patterns could give rise to EEG patterns and vice versa, and what could be the underlying mechanisms. In TGD framework on ecan consider alternatives for the identification of EEG resonance frequencies as resonance frequencies of nerve circuits and dark matter hierarchy challenges the earlier speculative TGD inspired models for sensory qualia and sensory organ. An updating of the capacitor model of the sensory receptor by replacing the capacitor with Josephson junctions between sensory organ and its magnetic body must be considered. The question arises whether sensory organs define not only sensory, but also corresponding cognitive and emotional representations. The fact that nerve pulses tend to destroy the temporal coherence of cognitive and emotional representations encourages the identification of glial cells and their magnetic bodies as carriers of higher level cognitive and emotional representations. The model of hearing leads to further ideas. For instance, the transformation of the sensory input to signals propagating along axonal microtubuli could make possible to feed sensory input into brain and possibly back to sensory organs at least in the case of vision and hearing.

2. Features

Walter Freeman has identified spatially amplitude modulated synchronous but non-periodic EEG patterns serving as correlates for conscious percepts. The identification as MEs is possible and the spectrum of durations for the synchronous time patterns encourages the interpretation of these patterns as an electromagnetic realization of genetic code words. A compression of memetic code words defined by the nerve pulse patterns giving rise to abstraction and classification would be in question. The representation would be achieved by the amplitude modulation of the alpha waves by higher harmonics of alpha frequencies. In the case of hearing the contraction seems to be un-necessary and memetic code could perhaps be realized also at the level of features. This would explain the completely exceptional role of the language in cognition.

3. Synchronization

Synchronization in and between various cortical areas is known to occur with millisecond precision. Also disjoint brain regions can be in synchrony. This is difficult to understand without synchronizing agent oscillating at kHz frequency. In TGD framework magnetic body is the natural agent inducing the synchrony and MEs could induce the synchronization. Synchronization would naturally occur at the frequency corresponding to a duration of the bit of the memetic code.

4. Stochastic resonance

Concerning the mapping of EEG frequencies to nerve pulse patterns, stochastic resonance promotes itself as a basic mechanism. In bistable systems stochastic resonance allows to amplify very weak periodic signals by utilizing white noise. Stochastic resonance is known to be relevant also at the neuronal level as demonstrated by the autocorrelation functions for spike sequences exhibiting peaks at the harmonics of the signal frequency. Neuron is however far from being bistable system, and this raises the question whether bi-stability might be present at some deeper quantal level.

5. Temporal codings

The conventional view that the information content of conscious experience is determined completely by rate coding from nerve pulse patterns does not seem plausible in TGD framework. Indeed, p-adic cognitive codes define an entire hierarchy of binary codes associated with the p-adic frequencies and frequency coding would apply only to the average intensity of the sensory input. For high stimulus intensities the duration of the bit of the p-adic cognitive codeword tends to become shorter. This is comparable to the increase of the speech rate during a high state of arousal, and conforms with the observed shift of EEG towards higher frequencies in this kind of situation. There is a lot of experimental evidence supporting the existence of various kinds of temporal codings, and these codings are discussed in TGD framework.

6. Scaling law

Scaling law provides bird's eye view about transitions which can represent conscious-to-us qualia at given level of the p-adic self hierarchy. The law relates two levels of self hierarchy corresponding to mental images associated with magnetic bodies of astrophysical size and with physical bodies, the latter with size not much larger than brain size. Scaling law assumes that self sizes L at given p-adic level k are between the p-adic length scales $L(k)$ and $L(k(next))$. Scaling law is of form $L = v/f$ and relates ELF self size characterized by ELF frequency f to the self size L and to the effective phase velocity v of the EEG wave.

Scaling law is also suggested by the experimental work with the effects of ELF radiation in water. Scaling law can be explained in terms of phase transitions transforming large h_{eff} photons to ordinary ones and vice versa. The chapter ends with the discussion about possible implications of the scaling law concerning EEG.

TGD leads to a proposal that the values of h_{eff} are such that energy spectrum of the cyclotron photons does not depend on the mass of the ion. This implies a universal energy spectrum and there are reasons for the hypothesis that biophotons result in the energy conserving transformations of dark photons to ordinary ones.

EEG and the structure of magnetosphere

Roughly 15 years ago I proposed the idea that Earth's magnetosphere (MS) could serve as a sensory canvas in the sense that biological systems, in particular the vertebrate brain, could have

sensory representations realized at the "personal" magnetic body (MB) closely associated with the MS of the Earth. EEG would make communications to and control by MB possible.

At that time I did not yet have the idea about number theoretical realization of the hierarchy of Planck constants $h_{eff} = nh_0$ in the framework of adelic physics fusing the physics of sensory experience and cognition. This hierarchy is crucial for understanding the basic aspects of living matter such as metabolism, coherence in long scales, correlates of cognition, and even evolution.

Also the concept of zero energy ontology (ZEO) forming now the basis of the quantum TGD was missing although there was already the about communication to past using negative energy signals. ZEO is now in a central role in the understanding of self-organization - not only the biological one. The new view about time predicting that time reversal occurs in ordinary state function reductions (SFRs) allows to understand homeostasis as self-organized quantum criticality.

For these reasons it is interesting to consider the notion of sensory canvas from the new perspective. This article discusses besides the earlier ideas about the MS also the proposal that it is possible to associate EEG bands to the regions of MS via the correspondence between EEG frequency with the distance of the region from Earth. Also the idea that the structure of MS could be a fractal analog of the vertebrate body is tested quantitatively by comparing various scales involved.

TGD Inspired Model for Nerve Pulse

The basic idea behind the model of nerve pulse is that some kind of quantum jump reduces the magnitude of membrane potential below the threshold leading to the generation of nerve pulse. Several identification of this quantum jump have been discussed during years but no really convincing option has been found. The evolution of ideas about dark matter hierarchy and associated hierarchy of Planck constants led to a breakthrough in several sectors. The assignment of long ranged classical weak and color gauge fields to dark matter hierarchy was the crucial step and led among other things to a model of high T_c superconductivity predicting the basic scales of cell, to a generalization of the genetic code to a hierarchy of genetic codes.

1. Background

The basic philosophy behind the model is following.

1. In TGD Universe the function of EEG and its variants is to make possible communications from the cell membrane to the magnetic body and the control of the biological body by the magnetic body via magnetic flux sheets traversing DNA by inducing gene expression. This leads to the notions of super- and hyper-genome predicting coherent gene expression at level of organs and population.

2. The assignment the predicted ranged classical weak and color gauge fields to dark matter hierarchy was a crucial step in the evolution of the model, and led among other things to a model of high T_c superconductivity predicting the basic scales of cell, and also to a possible generalization of EXG to a hierarchy of ZXGs, WXGs, and GXGs corresponding to Z^0, W bosons and gluons.

3. Dark matter hierarchy and the associated hierarchy of Planck constants play a key role in the model. For instance, in the case of EEG Planck constant must be so large that the energies of dark EEG photons are above thermal energy at the physiological temperature. The assumption that a considerable fraction of the ionic currents through the cell membrane are dark currents flowing along the magnetic flux tubes explains the strange findings about ionic currents through cell membrane. Concerning the model of nerve pulse generation, one input comes from the model of DNA as a topological quantum computer and experimental findings challenging Hodgkin-Huxley model as even approximate description of the situation.

4. The identification of the cell interior as gel phase containing most of water as structured water around cytoskeleton - rather than water containing bio-molecules as solutes as assumed in Hodkin-Huxley model - allows to understand many of the anomalous behaviors associated with the cell membrane and also the different densities of ions in the interior and exterior

of cell at qualitative level. The proposal of Pollack that basic biological functions involve phase transitions of gel phase generalizes in TGD framework to a proposal that these phase transitions are induced by quantum phase transitions changing the value of Planck constant. In particular, gel-sol phase transition for the peripheral cytoskeleton induced by the primary wave would accompany nerve pulse propagation. This view about nerve pulse is not consistent with Hodkin-Huxley model.

5. Pollack's experiments [**?**]emonstrate the existence of what he calls the fourth phase of water. This phase contains negatively charged regions - exclusion zones - serving in TGD Universe as candidates for prebiotic cells. The positive charge resides outside the exclusion region at the flux tubes of the magnetic body associated with the exclusion zones as dark proton strings defining dark nuclei realizing vertebrate genetic code [K49]. This vision leads to a generalization of the model of cell membrane Josephson junctions assignable to transmembrane proteins. Josephson energy becomes sum of Coulombic term and difference of cyclotron energies at the two sides of the membrane. The thermodynamical model for cell membrane is replaced with its "square root" forced by Zero Energy Ontology, and means the replacement of Boltzmann weights with their square roots appearing in the wave functions for dark particles. The phase transitions changing Planck constant change the equilibrium distributions of ions and this process should be behind the generation of nerve pulse.

2. New view about nerve pulse generation

The basic hypothesis has been that quantum jump takes the resting potential below the threshold for the generation of nerve pulse. One can imagine several manners for how this could happen. For years ago I learned 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) 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 solitonic 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. 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.

   In the microscopic description continuous Josephson junction is replaced with a distribution of Josephson junctions defined by transmembrane proteins such acting as pumps and channels.

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. Nerve pulse itself would correspond to a phase transition changing the value of Planck constant h_{eff} at the either side or both sides of the cell membrane at the flux tube associated

with the transmembrane protein. This would induce transition to a new ionic equilibrium since cyclotron energies for ions change. This transition would give rise to the change of the membrane potential. Cyclotron energy difference would however dominate in the generalized Josephson energy. This phase transition should be adiabatic and should not require heat or generate it.

4. 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 solitonic 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.

5. New physics would enter in several manners. Ions should form Bose-Einstein cyclotron condensates. The assumption of only bosonic ions leads to a highly predictive model. The new nuclear physics predicted by TGD predicts that ordinary fermionic ions (such as K^+, Na^+, Cl^-) have bosonic chemical equivalents with slightly differing mass number. 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.

3. The function of neural transmitters

TGD leads to a general view about the functions of membrane oscillations, nerve pulse and neural transmitters. Electromagnetic membrane oscillations induced by Z^0 MEs provide a realization of the memetic code as a fundamental cognitive code. The binding of various information molecules to the corresponding receptors gives rise to neuronal qualia analogous to tastes and odors but providing information about external world whereas ordinary receptors give information about nearby environment. At our level of hierarchy these qualia probably correspond to emotions in consistency with the finding that neurotransmitters can be identified as information molecules. Neurotransmitters might be also seen as conscious links in quantum web. The view that inhibition actually requires active energy feed and that excitation occurs automatically in the absence of the energy feed and induces entanglement with environment, is defended. This view conforms with Huxley's vision about brain as a filter inhibiting conscious experiences.

4. Microtubular level

The view about what happens at the micro-tubular level during synchronous neuronal firing relies on a many-sheeted model for sol-gel phase transitions as conscious bits and on the seesaw mechanism of remote metabolism according to which sol-gel transitions induces gel-sol transitions elsewhere in the cell and vice versa. Micro-tubular surfaces can be seen as analogs of cortical sensory and motor areas providing kind of conscious log files about sensory and motor history of the cell in terms of conformational transitions of tubulin dimers representing conscious bits.

What happens at the micro-tubular level during the nerve pulse, how gel phase differs from sol phase, and what occurs in sol-gel transition, belong to the principal challenges for quantum theories of consciousness. Charge entanglement associated with various bosonic ions allows to tackle these questions. The Bose-Einstein condensates of hydrogen atoms at tubular $k = 139$ space-time sheets form a bundle behaving like a liquid crystal identifiable as the gel phase. Positive and negative energy IR photons at energy of .1 eV belong to the predicted fractal hierarchy of metabolic currencies, and allow to control the stability of this B-E condensate so that a precisely targeted control of the cellular state by local sol-gel transitions becomes possible. Albrecht-Buehler has demonstrated that photons with this energy have a maximal effect on cells.

Negative energy MEs are especially important: they make possible intentional action at the micro-tubular level, they are crucial for the understanding of the micro-temporal quantum coherence, and have also inspired the notions of remote metabolism and quantum credit card. The newest discovery along this line is what might be called seesaw mechanism of energy metabolism. Seesaw mechanism minimizes dissipative losses and allows to understand how micro-tubular surfaces provide dynamical records for the cellular sol-gel transitions, and thus define fundamental micro-tubular representation of declarative long term memories. Also the notion of micro-tubuli as quantum antennae becomes precisely defined.

The model of DNA as topological quantum computer brings in a new element. Microtubule-axonal membrane system could perform topological quantum computation just as DNA-membrane (nuclear and perhaps also cell membrane) system has been proposed to do. The braiding of the magnetic flux tubes connecting microtubules to axon would define tqc programs and also provide a representations for sensory input from sensory organs in time scale shorter than millisecond if one assumes that gel-sol-gel transition of microtubule accompanies the nerve pulse. Whether one it one say that nerve pulse is initiated at microtubular or axonal level or by both collectively is not clear since the magnetic flux tubes connecting these two systems make them to act like single coherent whole.

Some New Aspects of the TGD Inspired Model of the Nerve Pulse

In this article various aspects of the TGD inspired model of nerve pulses are discussed.

1. Nerve pulses relate closely to the communications from the cell membranes to the magnetic body (MB) of the system using dark, frequency modulated Josephson radiation inducing at MB a sequence of cyclotron resonances serving as control signals and eventually giving rise to nerve pulse patterns. This would generalize the "right brain signs-left brain talks" metaphor. Also the model of meV spikes appearing in preneural systems is discussed.

2. Quantum gravitation in the TGD sense a can assign the needed huge values of h_{eff} to the gravitational magnetic bodies. Quantum gravitational flux tubes assignable to the Sun, Earth, and perhaps also other planets and even the Moon could be highly relevant for the living cell and the brain.

3. The connection with microtubular level is considered and the transfer of charged particles between microtubules and very long gravitational flux tubes assignable to them allows to induce membrane oscillations and even nerve pulse.

4. Zero Energy Ontology (ZEO) and Negentropy Maximization Principle (NMP) could allow computers to become effectively living intelligent systems able to reach goals by an analog of trial and error process. This requires the failure of quantum statistical determinism. This is the case if the gravitational Compton time defining a lower bound for the gravitational quantum coherence time is longer than the clock period of the computer. MB would play a key role also in the case of living computers and dark Josephson radiation could serve as a communication tool. Superconducting computers have Josephson junctions as basic active elements and are more promising than transistor based computers.

5. Also the recent finding that the neuronal system is in a certain sense 11-dimensional is discussed in the TGD framework. The basic observation is that the 12-neutron system, with neurons assignable to the 12 vertices of icosahedron and defining 11-D simplex, could be involved. Icosahedron and tetrahedron appear also with the TGD based model of bioharmony serving also as a model of the genetic code.

Part I

QUANTUM NEUROSCIENCE IN TGD UNIVERSE

Chapter 2

Quantum Mind and Neuro Science

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.

1. 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.

2. 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.

   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.

3. 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 ways 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. The key element is the huge vacuum degeneracy which implies that preferred non-vacuum extremals of Kähler action form a 4-D spin glass phase. The basic implications following from the extreme non-linearity of Kähler action is that normal derivatives of imbedding space coordinates at 3-D light-like orbits of partonic 2-surfaces and at space-like 3-surfaces at ends of CDs are many-valued functions of canonical momentum densities: this is one of the reasons that forced to develop physics as an infinite-D Kähler geometry vision instead of trying to develop path integral formalism or canonical quantization. A convenient way to treat the situation is to introduce local many-sheeted covering of embedding space such that the sheets are completely degenerate at partonic 2-surfaces. This leads in natural ways to the hierarchy of Planck constants as effective hierarchy hierarchy and integer multiples of Planck constants emerge naturally.

4. 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 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. The hologram idea has also rather abstract mathematical generalizations inspired by TGD. Infinite primes lead to the idea that each space-time point has a complex number theoretic anatomy and that one could see evolution also as evolution of this number theoretic anatomy. Quantum Mathematics replacing elements of number fields with Hilbert spaces characterizing their number theoretic anatomy is very similar idea and leads to holography also since one can replace the points of Hilbert spaces involved with Hilbert spaces repeatedly. In both cases this process is analogous to a repeated second quantization.

5. p-Adic physics can be identified as physics of cognition and intentionality. The hierarchy of p-adic length scales predicts a hierarchy of universal metabolic quanta as increments of zero point kinetic energies. 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. An attractive idea is that the negentropic entanglement can be assigned with magnetic flux tube and that ATP serves as a correlate for negentropic entanglement. This leads to a rather detailed ideas about the role of phosphate bond and provides interpretation for the fact that the number of valence bonds tend to be maximized in living matter. In a loose sense one could even call ATP a consciousness molecule.

6. The view about the function of brain differs from the standard view. The simplest option is that brain is builder of symbolic representations building percepts and giving them names rather than the seat of primary qualia relevant to our conscious experience. Sensory organs would carry our primary qualia and brain would build sensory percepts as standardized mental images by using virtual sensory input to the sensory organs. The new view about time is absolutely essential for circumventing the objections against this vision. The prediction is that also neuronal and even cell membranes define sensory maps with primary qualia assignable to the lipids serving as pixels of the sensory screen. These qualia would not however represent our qualia but lower level qualia. At this moment it is not possible to choose between thet two options. The role of EEG and its various counterparts at fractally scaled frequency ranges is to make possible communications to the various onion-like layers of the magnetic body and the control by magnetic body. Dark matter at these layers could be seen as the intentional agent and sensory perceiver.

In the following I briefly summarize some applications. I am of course forced to leave details to the books about TGD inspired theory of consciousness at my homepage [K102, K17, K73, K46, K16, K56, K59, K93].

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` [L14].

2.2 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 [K2]. 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 [**?**], and 160 Hz to cerebellar synchrony [**?**]. 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 [K79] remain to be disentangled.

3. The understanding of the Negentropy Maximization Principle [K61] and the role of negentropic 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 [K11]. 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 [L16]. 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).

2.2.1 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 [K79] 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.

2.2.2 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 [K2].

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 [C1]. 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 [**?**]). 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 [K85]. 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.

2.2.3 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.

2.2.4 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 [K79]. 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 [**?**] 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.

2.2.5 Recent TGD based view about qualia

The TGD inspired theory of qualia [K45] 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 [K61] 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.

2.3 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 [K79].

2.3.1 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 [I54] 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 [L3], [L3] 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 [L3] , [L3]

$$\gamma = 3J - \frac{p}{2}Z^0 \quad , \quad Q_Z = I_L^3 - pQ_{em} \quad , \quad p = sin^2(\theta_W) \tag{2.3.1}$$

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

$$f_\nu = \frac{m_e}{m_\nu}\frac{1}{2sin^2(\theta_W)}f_e \quad .$$

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 [**?**] 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 [J1]. 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

$E(Ion)/eV$	$V = -40\ mV$	$V = -60\ mV$	$V = -70\ mV$
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 2.1: 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.

$$\begin{aligned}(\frac{Z-N}{4} - pZ)Z^0 + q_{em}\gamma &= Q_{eff}\gamma \ , \\ Q_{eff} &= -\frac{Z-N}{2p} + 2Z + q_{em} \ . \end{aligned} \tag{2.3.2}$$

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 11.3** 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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2.3.2 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 [L47, **?**]. 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 11.3** 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 [**?**] 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 2.2**.

1. The resting potential for photoreceptors is $V = -40$ mV [**?**]. 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 [**?**], 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 11.3** shows.

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 2.2: 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.

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 [L4]. 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 $E_J = V_{rest}/2p = 2.086 \times V_{rest}$.

2.4 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 [I5] (`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.

2.4.1 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 [L16].

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 [H6, 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 [H6, 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...

2.4.2 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 [K49, L4].

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 [**?**].

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 [H6, 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).

2.4.3 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: $ZeV \to ZeV+\mu_I$. 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 $E_c = \hbar_{eff} ZeB_{end}/m$ 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 [K45] 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

$$\frac{\Delta f}{f} \simeq \frac{2f_{J,n}}{f_c + f_{J,n}} = \frac{2f_{J,1}}{nf_c + f_{J,1}} \ .$$

   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

$$\frac{\Delta f}{f} \simeq \frac{2ZeV}{E_{bio} + ZeV} \ .$$

   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 [K96] explaining anomalously large gravimagnetic effect claimed by Tajmar *et al* [E7, E11] 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 [K54] 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 [K77].

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 [K49, L4] 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.

2.4.4 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 [K75] [L20]. 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 [K79]. 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.

2.5 Constraints On The Fermionic Realization Of Genetic Code From The Model For Color Qualia

The original model for DNA as topological quantum computer assigns to DNA nucleotides quarks at ends of flux tubes or quark pairs at the ends of wormhole flux tubes. This is only the realization that came first to my mind in TGD Universe where dark variants of quarks can define QCD like physics even in cellular length scales. One can actually imagine several realizations of the genetic code and the first realization is far from being the simplest one. It is enough to have four different particles or many-particle quantum states to build at least formally a map from A, T, C, G to four states. It is obvious that the number of possible formal realizations is limited only by the imagination of the theoretician. Additional conditions are required to fix the model.

2.5.1 Fermionic Representation

Consider first the fermionic representations in the general case without specifying what fermions are.

1. The original proposal was that DNA nucleotides correspond to flux tubes with quark q and antiquark $\overline{q}$ at the ends of the parallel flux sheets extremely near to each other. Second options relies on wormhole magnetic flux tubes in which case quark pair $q\overline{q}$ is at both ends. Quarks u, d and their antiquarks would code for A, T, C, G. The spin of quarks is not taken into account at all in this coding: why not restrict the consideration to single quark. The total quark charge at given end of flux tube pair vanishes and flux tube ends carry opposite quark charges.

   The nice feature of this option is that one could understand the generation of color qualia in the model of sensory receptor in simple manner to be discussed below. Even if one accepts the arguments supporting the view that dark quarks in cell scale are natural outcome of the hierarchy of Planck constants, one could argue that the presence of both quarks and antiquarks does not conform with matter antimatter asymmetry (not that one can however identify the analog of matter antimatter asymmetry at DNA level).

2. Spin states for fermion pairs assigned with two parallel magnetic flux tubes with the magnetic field generated by spin provide much simpler representation for nucleotides. Similar fermion pair would reside at the second end of flux tube pair.

   (a) It is is essential that rotational symmetry is broken and reduces to rotational symmetry around the direction of flux tubes so that spin singlet and spin 0 state of triplet mix to form states for which each fermion is in spin eigenstate. The states must be antisymmetric under exchange of the protons and spin 1/0 states are antisymmetric/symmetric in spatial degrees of freedom (wave functions located to the ends of flux tubes). The states with definite spin for given flux tube are mixtures of s=1 states with vanishing spin projection and s=0 state.

   (b) It is not quite clear whether one should treat fermion pairs as identical bosons with 3+1 spin states since in TGD framework one considers disjoint partonic 2-surfaces and the situation is not that of QFT in M^4. This interpretation would require totally symmetry of the states under permutations of bosonic states defined by the 3+1 spin states. Coding by spin requires that each nucleotide corresponds to a state with a well defined spin. In field theory language the state would be obtained by applying bosonic oscillator operators generating states of given spin localized to a given nucleotide position.

(c) The classical correlate for the permutations of coordinates of fermions has interpretation as braiding for the flux tubes of the flux tube pair. In the similar manner the permutation of the flux tube pairs associated with nucleotides has interpretation as braiding of the 3-braids formed form from flux tube pairs. Braiding therefore gives a representation of spin analogous to the well-known orientation entanglement relation invented by Dirac and providing geometric representation of spin 1/2 property.

2.5.2 Various Options For The Fermionic Representation Of A, T, C, G

Fermionic representations allows several options since fermion can be electron, u or d quark, or proton. Wormhole magnetic fields would not be needed in this case.

1. The problem of electron and proton options is that it does not allow realization of color qualia. There is also the well-known problem related to the stability of DNA caused by the phosphate charge of -2 units per nucleotide. Somehow this charge should be screened. In any case, the charge -2 should correspond to the electron pair at the DNA end of the flux tube for electron option. For proton option the charge would be screened completely. One could of course consider also the large $\hbar$ color excitations of ordinary protons instead of quark at its nucleotide ends. This option would however require the modification of quark wave functions inside proton and this option will not be discussed here.

2. Quark option would give rise to both color and allow also to reduce the electronic charge of -2 units by 4/3 units to -2/3 units in the case of u quark pair. This would help to stabilize DNA. In the case of d quarks the charge would increase to -10/3 units and is not favored by stability argument. Flux tube pairs assigned to single nucleotide define diquarks with spin 1 or spin 0.

   (a) Diquarks behave ass identical bosons with 3+1 spin states and 3×3 color states. The states with well defined symmetry properties in spin degrees of freedom have such properties in spatial degrees of freedom. This means that one obtains a superposition of flux tube pairs with are either braided or unbraided. Triplet/singlet state is symmetric/antisymmetric and total asymmetry could be guaranteed by assuming symmetry/antisymmetry in spatial degrees of freedom and antisymmetry/symmetry in color degrees of freedom. This would give anti-triplet/6-plet in color degrees of freedom. Spatial symmetry would favor antitriplet and diquark would behave like antiquark with respect to color. Let us assume antitriplet state for definiteness.

   (b) DNA codon corresponds to three-di-quark state. This state must be totally symmetric under the exchange of bosons. One can have total symmetry in both spatial and color degrees of freedom or total antisymmetry/symmetry in spatial and total antisymmetry/symmetry in color degrees of freedom.The first option gives 10-dimensional color multiplet and the second one color singlet. Braiding is maximal and symmetric/antisymmetric in these case. One can consider also mixed symmetries. In this case one has color octet which is antisymmetric with respect to the first nucleotide pair and symmetric with respect to first nucleotide pair and third nucleotide. The braiding of the first two nucleotides must be antisymmetric and the braiding of this pair with third nucleotide. The conclusion would be that color multiplets correspond to well defined braidings and one would therefore have directed connection with topological quantum computation. Color octet is especially interesting concerning the representation of color qualia.

The challenge of all these options (note that the representability of color selects quark option) is to find a good justification for why the assignment of A, T, C, G to quark states or spin states is unique dynamically. Stability argument is expected to help here.

2.5.3 Realization Of Color Qualia For Quark Option

Consider now how one could understand the generation of qualia for quark option.

1. The generation of qualia involves interaction with external world giving rise to a sensory percept. In the case of visual colors it should correspond to a measurement of quark color and should give rise to eigenstages of color at the ends of flux tubes at DNA nucleotides for a nucleus or cell of photoreceptor. A modification of capacitor model is needed. Color polarization is still essential but now polarization in nucleus or cell scale is transformed in the generation of color quale to a polarization in longer length scale by the reconnection of flux tubes so that their ends attach to "external world". The nucleus/cell becomes color and state function reduction selects well defined quantum numbers. It is natural to assume that the entanglement in other degrees of freedom after color measurement is negentropic.

2. Does the "external world" correspond to another cell or to the inner lipid layers of the cell membrane containing the nucleus. In the first case flux tubes would end to another cell. If the nuclei of receptor cells are integrate to a larger structure by magnetic flux sheets traversing through them one can also consider the possibility that the polarization in the scale of cell nucleus (recall that the nucleus has also double lipid layer) is transformed to a polarization in cell scale so that similar process in cell scale gives rise to qualia.

3. The entire receptor unit must have net color charge before the state function reduction. This requires that there are flux tubes connecting the receptor unit to a unit representing "external world" and having vanishing color charge. If second cell is the "external world" these flux tubes must go through the pair of lipid layers of both cell membrane and end up to the nucleus of cell in the environment. If external world correspond to the complement of nucleus inside cell the inner layers of cell membrane represents external world. Cell membrane indeed serves as sensory receptor in cell length scale. One can of course have sensory qualia in various length scales so that both options are probably correct and a kind of fractal hierarchy is very natural giving rise also to our qualia at some higher level. Living matter as conscious hologram metaphor suggests a fractal hierarchy of qualia.

   After state function reduction reducing the entanglement the flux tubes split and the receptor becomes un-entangled with external world and has vanishing color charges. At the level of conscious experience this means that there can be only memory about the quale experience. The sensation of quale lasts with respect to subjective time as long as the negentropic entanglement (see **Fig.** `http://tgdtheory.fi/appfigures/cat.jpg` or **Fig. ??** in the appendix of this book) prevails. There is an obvious analogy with Orch-OR (see `http://tinyurl.com/ylfv6pp`) proposal of Hameroff and Penrose in which also conscious experience ends with state function reduction.

4. Consider now how the color qualia are generated.

   (a) There must be two flux tube states. In the first state there are two flux tube beginning from cell nucleus A and ending to the inner lipid layer a_1 and flux tube beginning from the outer lipid layer a_2 and ending cell nucleus B. Both flux tubes have vanishing net color so that cells have vanishing net colors. This could be regarded as the resting state of the receptor. The lipids in layers a_1 and a_2 are connected by another short flux tube. Same for b_1 and b_2.

   (b) The second flux tube state corresponds to long flux tubes connecting the nuclei of cells A and B. The ends carry opposite color charges. In this case the net color of both A and B is non-vanishing. This state would be an outcome of a reconnection process in which the flux tubes from A to a_1 and B to a_2 re-connect with the short flux tube connecting lipid layers a_1 and a_2.

   (c) When these flux tubes carry opposite colors numbers at their ends, the cell possess net color charge and can represent color quale. Or rather, creation of this kind of flux tube connections would give rise to the color charging of the receptor cell with external world carrying opposite color charge.

One can argue that this mechanism is not quite in spirit with color capacitor model for sensory receptor. Polarization is still essential but now polarization in receptor scale is transformed

to polarization in longer length scale by the reconnection of flux tubes. The analog of di-electric breakdown however still applies in the sense that its analog induces large polarization. Several mechanisms generating larger polarization are of course possible. One can ask how essential the electromagnetic polarization of cell membrane is for the generation of qualia at cell level. Note also that biomolecules are quite generally polar molecules.

The unexpected prediction of the model is that braiding would correlate directly with qualia. This would mean also a connection between quantum computation and qualia. This condition emerges from Fermi/Bose-Einstein statistics correlating braiding with symmetric properties of color states and spin states. Quite generally, the correlation of braiding with the symmetries of wave functions as functions of points of braid end points would allow to have direct geometric correlate between induced entanglement and braiding as naïve intuitive expectations have suggested.

This model is not consistent with the naïve expectation that the quale is generated after state function reduction. Rather, the beginning of sensation of quale means beginning of negentropic entanglement and fusion with external world and state function usually associated with the quantum measurement would mean the end of the sensation and separation from the external world! Maybe one can say that state function reduction means that experience is replaced with a memory "I had the sensation of quale" ! Krishnamurti would certainly agree!

2.6 Model For Nerve Pulse

The basic idea behind the model of nerve pulse is that some kind of quantum jump reduces the magnitude of membrane potential below the threshold leading to the generation of nerve pulse. Several identifications of this quantum jump have been discussed during years but no really convincing option has been found. The evolution of ideas about dark matter hierarchy and associated hierarchy of Planck constants led to a breakthrough in several sectors. The assignment the predicted ranged classical weak and color gauge fields to dark matter hierarchy was the crucial step and led among other things to a model of high T_c superconductivity [K18, K19] providing interpretation for the basic scales of cell in terms of the p-adic length scale hypothesis and Gaussian Mersennes.

2.6.1 Background

The model for nerve pulse is discussed in detail in [K79]. TGD inspired model for high T_c superconductivity involving dark electrons with large $\hbar$ in an essential manner is a prerequisite for the model and is discussed in [K18, K19]. The basic philosophy behind the model discussed in detail in is following.

1. In TGD Universe the function of EEG and its variants is to make possible communications from the cell membrane to the magnetic body and the control of the biological body by the magnetic body via magnetic flux sheets traversing DNA by inducing gene expression. This leads to the notions of super- and hyper-genome predicting coherent gene expression at level of organs and population.

2. The assignment the predicted ranged classical weak and color gauge fields to dark matter hierarchy was a crucial step in the evolution of the model, and led among other things to a model of high T_c superconductivity predicting the basic scales of cell, and also to a generalization of EXG to a hierarchy of ZXGs, WXGs, and GXGs corresponding to Z^0, W bosons and gluons.

3. Dark matter hierarchy and the associated hierarchy of Planck constants plays a key role in the model. For instance, in the case of EEG Planck constant must be so large that the energies of dark EEG photons are above thermal energy at the physiological temperature. The assumption that a considerable fraction of the ionic currents through the cell membrane are dark currents flowing along the magnetic flux tubes explains the strange findings about ionic currents through cell membrane. Concerning the model of nerve pulse generation, the newest input comes from the model of DNA as a topological quantum computer and experimental findings challenging Hodgkin-Huxley model as even approximate description of the situation.

4. The identification of the cell interior as gel phase containing most of water as structured water around cytoskeleton - rather than water containing bio-molecules as solutes as assumed in Hodkin-Huxley model - allows to understand many of the anomalous behaviors associated with the cell membrane and also the different densities of ions in the interior and exterior of cell at qualitative level. The proposal of Pollack [I47] that basic biological functions involve phase transitions of gel phase generalizes in TGD framework to a proposal that these phase transitions are induced by quantum phase transitions changing the value of Planck constant. In particular, gel-sol phase transition for the peripheral cytoskeleton induced by the primary wave would accompany nerve pulse propagation. This view about nerve pulse is not consistent with Hodkin-Huxley model.

2.6.2 New View About Nerve Pulse Generation

The basic hypothesis has been that quantum jump takes the resting potential below the threshold for the generation of nerve pulse. One can imagine several ways for how this could happen. According to [**?**] 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) leads to a rather precise model for the generation of nerve pulse [K79].

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 solitonic 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. 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 1 kHz soliton sequence. The velocity of 1 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 1 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 solitonic velocity could be interpreted as drift velocity. This also inspires a generalization of the model of DNA as TQC since 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 [K11]. Ions should form Bose-Einstein cyclotron condensates. The new nuclear physics predicted by TGD predicts that ordinary fermionic ions (such as K^+, Na^+, Cl^-) have bosonic chemical equivalents with slightly differing mass

number. Anomalies of nuclear physics and cold fusion provide experimental support for the predicted new nuclear physics [L4]. 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 dark scaled up variants of ordinary $W^{\pm}$ bosons is a natural manner to achieve this if new nuclear physics is indeed present. A lot of unknown is involved but model builder assuming that dark matter is responsible for the special properties of living matter must tolerated this.

2.6.3 The Function Of Neural Transmitters

TGD leads to a general view about the functions of membrane oscillations, nerve pulse and neural transmitters. The binding of various information molecules to the corresponding receptors gives rise to neuronal qualia analogous to tastes and odors but providing information about external world whereas ordinary receptors give information about nearby environment. At our level of hierarchy these qualia probably are coded to emotions in consistency with the finding that neurotransmitters can be identified as information molecules. Neurotransmitters might be also seen as conscious links in quantum web.

2.6.4 Microtubular Level

The view about what happens at the micro-tubular level during synchronous neuronal firing relies on a many-sheeted model for sol-gel phase transitions as conscious bits and on the seesaw mechanism of remote metabolism according to which sol-gel transitions induces gel-sol transitions elsewhere in the cell and vice versa. Micro-tubular surfaces can be seen as analogs of cortical sensory and motor areas providing kind of conscious log files about sensory and motor history of the cell in terms of conformational transitions of tubulin dimers representing conscious bits.

What happens at the micro-tubular level during the nerve pulse, how gel phase differs from sol phase, and what occurs in sol-gel transition, belong to the principal challenges for quantum theories of consciousness. Charge entanglement associated with various bosonic ions allows to tackle these questions. The Bose-Einstein condensates of hydrogen atoms at tubular $k = 139$ space-time sheets with size scale of 5 Angstrom ($p \simeq 2^k$ labels space-time sheets for which electronic Compton scale $L_e(k) = \sqrt{5}L(k)$ is given by $L_e(k) = 2^{(151-k)/2}L_e(151)$, where $L_e(151) \simeq 10$ nm corresponds to cell membrane thickness) form a bundle behaving like a liquid crystal identifiable as the gel phase. Positive and negative energy IR photons at energy of.1 eV belong to the predicted fractal hierarchy of metabolic currencies, and allow to control the stability of this B-E condensate so that a precisely targeted control of the cellular state by local sol-gel transitions becomes possible. Albrecht-Buehler has demonstrated that photons with this energy have a maximal effect on cells.

Negative energy MEs (topological light rays) are especially important: they make possible intentional action at the micro-tubular level, they are crucial for the understanding of the micro-temporal quantum coherence, and have also inspired the notions of remote metabolism and quantum credit card. The newest discovery along this line is what might be called seesaw mechanism of energy metabolism. Seesaw mechanism minimizes dissipative losses and allows to understand how micro-tubular surfaces provide dynamical records for the cellular sol-gel transitions, and thus define fundamental micro-tubular representation of declarative long term memories. Also the notion of micro-tubuli as quantum antennae [K70] becomes precisely defined.

The model of DNA as topological quantum computer [K2] brings in a new element. Microtubule-axonal membrane system could perform topological quantum computation just as DNA-membrane (nuclear and perhaps also cell membrane) system has been proposed to do. The braiding of the magnetic flux tubes connecting microtubules to axon would define TQC programs and also provide a representations for sensory input from sensory organs in time scale shorter than millisecond if one assumes that gel-sol-gel transition of microtubule accompanies the nerve pulse. The entire sensory pathway from sensory receptor to brain would define linear representations of nerve pulse patterns and this might explain why the lengths of sensory pathways are maximized. Whether one it one say that nerve pulse is initiated at microtubular or axonal level or by both collectively is

not clear since the magnetic flux tubes connecting these two systems make them to act like single coherent whole.

2.7 Model For EEG

The emergence of zero energy ontology, the explanation of dark matter in terms of a hierarchy of Planck constants requiring a generalization of the notion of embedding space, the view about life as something in the intersection of real and p-adic worlds, and the notion of number theoretic entanglement negentropy led to a breakthrough in TGD inspired quantum biology and also to the recent view of qualia and sensory representations including hearing allowing a precise quantitative model at the level of cell membrane.

Also long range weak and color forces play a key role. Long range weak forces 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 far form vacuum extremals with large Planck constant classical Z^0 fields are very weak and long range color forces strong. In this phase color forces are very weak. This leads to a correct prediction for the frequencies of peak sensitivity for photoreceptors - something highly non-trivial remembering that also the large parity breaking effects in living matter find a natural explanation. Second quantitative key observation was that for electrons and quarks the time scales of causal diamonds correspond to fundamental biorhythms assignable to central nervous system.

The general model for EEG follows neatly from this picture combined with the general model of high T_c superconductivity. A fractal hierarchy of EEGs extending over a wide frequency range beginning from visible photon frequencies and its generalizations identified in terms of Josephson radiation is predicted with levels labeled by p-adic length scales and the value of $\hbar$ at various levels of dark matter hierarchy. Cell membrane would represent only one level in this hierarchy. Besides EEG one would have its counterparts for various organs, organelles and even cell. Also the possibility of ZEG, WEG and QEG corresponding to Z^0 bosons, W bosons, and gluons must be considered. The fractal hierarchy of EEGs is described in two chapters of the book "TGD and EEG" [K38, K81].

2.7.1 Fractal Hierarchy Of EEGs

EEG is replaced with a fractal hierarchy of EEGs corresponding to various values of Planck constants involved.

1. There are three contributions to EEG besides the contributions due to the neural noise and evoked potentials. These contributions correspond to Schumann frequencies, cyclotron frequencies f_c of biologically important ions in magnetic field $B_{end} = .2$ Gauss, and to the Josephson frequencies f_J associated with Josephson junctions assigned with cell membranes. If Josephson radiation modulates cyclotron radiation also the frequencies $mf_J \pm nf_c$ appear in the spectrum.

2. In standard model $f_J = ZeV/\hbar$ would determined by the membrane potential and would correspond to energy in infrared. This sounds completely reasonable. TGD however suggests that cell membrane as a critical system correspond to an almost vacuum extremal. This predicts classical Z^0 field proportional to em field to which nuclei and neutrinos are assumed to couple. This would explain chiral selection in living matter and predict correctly the frequencies of peak sensitivity for photoreceptors as Josephson frequencies assignable to the biologically most important ions. The effective couplings of ions to membrane potential are modified and the Josephson frequencies correspond to energies in visible and UV range. Bio-photons and EEG could be seen as manifestations of one and same thing: Josephson radiation with a large value of Planck constant with energies of bio-photons and frequencies of EEG.

3. An important point is that the ions involved must behave like bosons. For cyclotron condensates either Cooper pairs of ordinary fermionic ions or exotic ions chemically similar to their standard counterparts obtained from neutral bosonic atom by making one or more neutral color flux tubes connecting nucleons charged. For Josephson radiation only the latter

option works. TGD based nuclear physics indeed predicts this kind of nuclei and there is experimental evidence for their existence [L4].

4. For cyclotron frequencies the extremals are assumed to be far from vacuum extremals carrying very small classical Z^0 fields but non-vanishing classical W fields and color fields (with $U(1)$ holonomy). The corresponding flux quanta would naturally correspond to flux sheets traversing through DNA strands while Josephson radiation would propagate along flux tubes parallel to the cell membrane. Far from biological body one expects both kinds of flux quanta to fuse to form larger ones so that one has parallel space-time sheets carrying cyclotron *resp.* Josephson radiation. Wormhole contacts between Josephson and cyclotron flux sheets would induce a non-linear interaction giving rise to a superposition of harmonics of Josephson and cyclotron frequencies.

5. Josephson frequencies are assignable to the cell membrane and would naturally correspond to the communication of sensory data to the magnetic body. This would suggest that cyclotron frequencies are assignable to the magnetic flux sheets going through DNA strands responsible for quantum control via genome expression. This picture might be too naïve. Josephson radiation would induce transitions between cyclotron states should generate sensory representations at magnetic body so that both frequencies would be involved with sensory representations. Furthermore, the identification of motor action as time reversal of sensory perception allowed by zero energy ontology would mean that same mechanisms are at work for negative energies (phase conjugate radiation). Resonance is achieved if the condition $mf_J = nf_c$ is satisfied. For small values of integers m and n the condition is quite restrictive. Schumann frequencies can be assigned with the magnetic body of Earth and would correlate with the collective aspects of consciousness.

6. The model of hearing forces to assume quite a wide spectrum of Planck constants- at least the values coming as powers of two and the safest assumption is that at least integer multiples of the ordinary Planck constant are possible. Josephson radiation and cyclotron radiation have same scale if $B_{end} \propto 1/\hbar$ proportionality holds true. For 5 Hz Josephson frequency and membrane potential and for V=.70 mV corresponding to the resting potential of neuron one obtains $r = (0.96, 1.20, 1.34, 1.01) \times 2^{47}$. For Ca^{++} ion r is very near to a power of 2.

2.7.2 Basic Aspects Of EEG

Consider now how one could understand basic characteristics of EEG during wake-up and sleep in this framework.

1. For small amplitudes and for the lowest harmonics this implies that alpha band to which the cyclotron frequencies most biologically important bosonic ions correspond has as satellites theta and beta bands. Higher harmonics correspond to gamma and higher bands having also satellites.

2. For large amplitudes EEG becomes chaotic which is indeed the property of beta band during say intense concentration or anxiety. The findings of Nunez about narrow 1-2 Hz wide bands at 3, 5, 7 Hz and 13, 15, 17 Hz confirm with the prediction of satellite bands and fix the Josephson frequency to 5 Hz. This picture explains the general characteristics of EEG in wake-up state qualitatively and quantitatively.

3. In order to understand the characteristics during various stages of deep sleep one must assume that the cyclotron frequency scale of ions is scaled down by a factor of 1/2. The simplest explanation is that the value of Planck constant increases by a factor 2 in a phase transition having interpretation as a leakage of cell membrane space-time sheet between the pages of Big Book defined by the generalized embedding space. During stage 4 sleep only only DNA cyclotron frequencies in delta band are around 1 Hz and just above the thermal threshold are predicted to be present. This stage could correspond to a value of Planck constant which is 4 times its value in wake-up state.

The generalization of the model for EEG hierarchy to the case of ZEGs is straightforward and Josephson frequency spectrum is the same. Any atom, almost always boson, has an exotically charged counterpart with same statistics so that very rich spectrum of Bose-Einstein condensates results.

2.7.3 The Effects Of ELF EM Fields On Brain

The experimental data about the effects of ELF em fields at cyclotron frequencies of various ions in Earth's magnetic field on vertebrate brains were crucial for the development of the model of EEG. As a matter fact, it was the attempt to explain these effects, which eventually led to the discovery of the fractal hierarchy of EEGs and its generalizations.

The reported effects occur for harmonics of cyclotron frequencies of biologically important ions in Earth's magnetic field. They occur only in amplitude windows. The first one is around 10^{-7} V/m and second corresponds to the range $1 - 10$ V/m: the amplitudes of EEG waves are in the range 5-10 V/m. The effects are present only in the temperature interval 36-37 C.

1. Cyclotron frequencies led to the vision about cyclotron condensates of biologically important ions and their Cooper pairs at the flux quanta of dark magnetic field with so large Planck constant that the energies of cyclotron photons are above thermal threshold. The model for EEG and bio-photons in terms of Josephson radiation from cell membrane which is almost vacuum extremal allows to make this model more quantitative.

2. The temperature window has one interpretation in terms of a competition of almost vacuum extremal property of cell membrane possible above some critical temperature and high T_c super-conductivity possible below some critical temperature.

3. The amplitude window 10^{-7} V/m follows from a quantized form of Faraday law whose existence is supported by the fact that space-time sheets are analogs of Bohr orbits in exact sene. The quantisation condition relates the amplitude of electric field to Planck constant and frequency. For the value $r = \hbar/\hbar_0 = 2^{47}$ of Planck constant required by 5 Hz Josephson frequency the 10^{-7} V/m amplitude is predicted correctly.

4. The amplitude window around 1-10 V/m (EEG amplitudes are in the range 5-10 V/m) follows if the values of Planck constant in the range $10^7 r - 10^8 r$ can be justified. A possible justification is based on the observation that for $r_1 = 10^8 r$ the Compton wave length of intermediate gauge bosons corresponds to $k = 163$ defining Gaussian Mersenne and wavelength corresponding to 2 eV energy for photon which also corresponds to bio-photon energies assignable to 70 mV resting potential of neuron membrane. Electron's Compton length corresponds for $r_1 = 10^8 r$ to 28 cm, which defines the size scale of brain. One might hope that these findings could allow to build an internally consistent story about what happens.

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

I received a link to a rather baffling finding about brain [?] (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.

2.7.5 Vision About Biological Evolution And Evolution Of Brain

The proposed model for EEG, the idea that Gaussian Mersennes (four electron Compton lengths associated with them are in the range 10 nm-2.5 micrometers) define p-adic length scales allowing exotic variants of color and electro-weak physics with light intermediate gauge bosons at space-time sheets near vacuum extremals, and the assumption that the preferred values of Planck constant are such that they relate these p-adic scales to each other leads to a detailed quantitative vision about evolution of life as emergence of longer scales belonging to this hierarchy and as special case also to a vision about evolution of cell, nervous system, EEG, and long term memory. The increase of the largest Planck constant in the hierarchy of Planck constants associated with the organism would mean increase of the time scales of planned action and memory and therefore evolutionary leap. The model predicts a hierarchy of preferred size scales for various sub-systems of organisms and corresponding time scales identifiable in terms of bio-rhythms and memory span. Also cells and neurons could be classified according the their evolutionary level characterized by the largest Planck constant involved.

The evolution at our level of hierarchy would most naturally correspond to cultural evolution taking mainly place at the level of magnetic bodies responsible for higher levels of collective consciousness. This would explain why we differ so dramatically from our cousins although genomes are virtually identical. Evolution of quantum computer programs associated with DNA would be one aspect of this evolution.

2.7.6 Does Memory Code Exist?

Stuart Hameroff is one of the pioneers of the quantum conscious and quantum biology. Quite recently Hameroff and collaborators publishes a proposal for memory code based on microtubules. The simplest version would identify code words as 6 bit sequences just as in case of genetic code. The bit would be represented by the presence or absence of phosphate. TGD suggests a different interpretation in terms of flux tubes connecting microtubule surface with lipid layer and now the presence of ATP would mean that flux tube is in active state and gives rise to negentropic entanglement: see the article "A Proposal for Memory Code" (see `http://tinyurl.com/y9bh32tg`) [L7].

In an article in the March 8 issue of the journal PLoS Computational Biology, physicists Travis Craddock and Jack Tuszynski of the University of Alberta, and anesthesiologist Stuart Hameroff of the University of Arizona propose a mechanism for encoding synaptic memory in microtubules, major components of the structural cytoskeleton within neurons. The self-explanatory title of the article is "Cytoskeletal Signaling: Is Memory Encoded in Microtubule Lattices by CaMKII Phosphorylation?" (see `http://tinyurl.com/7dcgjwf`) [**?**].

The basic ideas of the model of the model of memory code are following.

1. The hexagonal cylindrical lattice of microtubule suggests the possibility of lattice consisting of bits and probably very many proposals have been made. One such idea is that bit is represented in terms of the two basic conformations of tubulin molecules called α and β. The recent proposal is that bit corresponds to the phosphorylation state of tubulin. Also a proposal that the bits form 6-bit bytes is considered: 64 different bytes are possible which would suggest a connection with the genetic code.

2. The motivation for the identification of byte is that CaMKII enzyme has in the active state insect like structure: 6 + 6 legs and the legs are either phosphorylated or not. This geometry is indeed very suggestive of connexion with 6 inputs and 6 outputs representing genetic codons representable as sequences of 6 bits. The geometry and electrostatics of CaMKII is complementary to the microtubular hexagonal lattice so that CaMKII could take care of the phosphorylation of microtubulins: 6 tubulins at most would be phosphorylated at one side. The presence of Ca^{+2} or calmodulin flux flowing to the neuron interior during nerve pulse is responsible for self-phosphorylation of CaMKII: one can say that CaMKII takes itself care that it remains permanently phosphorylated. I am not sure whether this stable phosphorylation means complete phosphorylation.

It is however difficult to imagine how Ca^{+2} and calmodulin flux could contain the information about the bit sequence and how this information could be coded in standard manner to phosphorylation pattern of legs. The only possibility which looks natural is that phosphorylation is a random process and only the fraction of phosphorylated legs depends on Ca^{+2} and calmodulin fluxes. Another possibility would be that the subsequent process of phosphorylation MT by completely phosphorylated CaMKII manages to do it selectively but it is very difficult to imagine how the information about codon could be transferred to the phosphorylation state of MT.

For these reasons my cautious conclusion is that phosphorylation/its absence cannot represent bit. What has been however found is a mechanism of phosphorylation of MTs, and the question is what could be the function of this phosphorylation. Could this phosphorylation be related to memory but in different manner? The 6+6 structure of CaMKII certainly suggests that the analog of genetic code based on 6 bits might be present but realized in some other manner. The presence of ATP would make a bit active and a rather natural expectation is that typically all bits are either in-active or active. This would give a direction connection with negentropic entanglement. The negative energy signal from future would naturally transform ATP to ADP and mean transfer of mental image made possible by negentropic entanglement to geometric now. The original mental image representing memory would be destroyed in accordance with no-cloning theorem.

2.8 Bio-Photons

MEs (massless extremals) can be carriers of light like vacuum currents generating coherent light. Bio-photons [I36, I68, I42] were the first proposed identification for this coherent light in living

matter [K70]. In absence of material about bio-photons I did not develop these ideas in any quantitative detail. Situation has changed with the development of web and recently I learned from Lian Sidorov about home page containing online articles of Fritz-Albert Popp and colleagues about bio-photons and related phenomena. I am grateful for Lian also for very useful discussions and keen questions helping me to become and stay conscious about the many poorly understood aspects of the "great vision". This homepage is recommended also to the reader and the data used below mostly derive from the articles therein [**?**].

2.8.1 What Bio-Photons Are?

The web articles [**?**] provide the basic facts about bio-photons and in the following I summarizes my novice view about bio-photons.

Bio-photons have frequencies in the range 200-800 nm (at least). The intensity of bio-photons is extremely low: from one photon to few hundred photons/cm^2s, which is 20 orders of magnitude weaker than common fluorescence of photophosphorence. There is evidence for coherent radiation also at longer wave length scales. A far from thermal equilibrium situation is in question: the intensity of photons is about 10^{10} times higher than that associated with the thermal visible photons at body temperature. The spectral density $f(\nu)$ defined as the counterpart of Boltzmann weight is essentially constant. This means that the effective temperature increases linearly with frequency. The experimental work of Popp and colleagues provides support for the view that bio-photons are indeed coherent light rather than some waste radiation resulting as a by-product of biological processes [**?**]. Poisson statistics for the number of photons in coherent state ($p_n = exp(-\alpha)\alpha^n/n!$) is the basic signature for the coherent light and it is found that photon counts obey this distribution.

Since $\tau \sim 1$ nanoseconds is the characteristic time constant for em emissions and absorptions at visible wave lengths, one can argue that the length scale $L = c\tau \sim 10$ cm defines the length scale below which it is not sensible to speak about localized photon and thus bio-systems must be treated as macroscopic quantum systems as far as coherent photons are considered. The timescale means also that 10^9 reactions per second can in principle catalyzed by absorption and emission of single photon in single cell: the typical number of reactions is 10^5 per second inside single cell [**?**] . If bio-photons Bose-Einstein condense at magnetic mirrors (ME-magnetic flux tube pairs), extremely sharp control of biological reactions could be indeed achieved. Of course, if Bose-Einstein condensed bio-photons are most important for bio-control, one cannot exclude the interpretation of the observed bio-photons as some kind of leakage radiation from living matter (of course, these bio-photons might serve communication purposes).

Even the wave length of the visible photons, which is somewhat below the cell size, implies that molecules see classical em field like boat sees the sea. One could argue that photons as CP_2 type extremals are essentially point-like. One the other hand, if MEs are classical correlates for photons or if the classical interaction of atoms and molecules with MEs is additional aspect of their interaction with em fields, this is not the case. The situation is not conceptually completely clear in this respect.

Interference effects provide also support for the notion of macroscopic coherent states. Popp proposes that in a healthy organism constructive interference tends to occur inside cells for bio-photons whereas destructive interference takes place outside [I67, I42]. Or stating it differently, cells are able to store visible bio-photons inside them. For healthy cells the bio-photon emission and well as delayed luminescence have been found to increase as a function of cell density up to some critical density and to decrease after that. For cancer cells the intensity increases indefinitely and nonlinearly [I67]. This supports the view that in cancer cell population bio-photons leak out and do not properly participate to the bio-control.

Bio-photon emission is a signature of living matter in the sense that the presence of oxidative process accompanies always the emission. This is true also for the delayed luminescence resulting as a delayed response to electromagnetic or some other perturbation. The dependence of the delayed luminescence on temperature suggests that the activation energy for the process controlling photoluminescence is roughly .53 eV [I81]: this is rather near to the energy .49 eV stored in the ATP molecule. The experiments involving the insertion of inert molecules to DNA indicate that DNA is a source of bio-photons [I40], [**?**]. The spectrum of bio-photons and delayed luminescence correlates strongly with various biological processes. For this reason bio-photons have several applications to

bio-search, food quality control, cancer research, pharmacology and heal prophylaxis.

2.8.2 Some Phenomena Related To Bio-Photons

There are several interesting and theoretically challenging phenomena involving bio-photons.

1. Delayed luminescence [I79, I65] results after an exposure to an external perturbation, which can be light or ultrasound. Delayed luminescence accompanies also biological processes like cell mitosis. The intensity of the coherent light varies from few photons to 10^5 photons/cm^2s. The characteristic feature of the delayed luminescence is hyperbolic ($I(t) \propto 1/(1+\lambda t)$) decay instead of the exponential one expected if incoming light just scatters from the system. The intensity involves oscillatory modulations with respect to a variable u which depends logarithmically on time coordinate ($u = log(1+\lambda t)$). As a function of cell density delayed luminescence increases up to some critical cell density for a healthy cell population and begins to decrease after that. For cancer cell population there is no such critical cell density.

2. Some animal populations can "see" each other. For instance, when populations of dinoflagellates become to optical contact they begin to flicker synchronously [I81] (also fireflies in mangrove trees in Thailand flicker in a synchronous manner). In TGD framework this could be interpreted as evidence for magnetic mirror bridges connecting the populations such that the MEs associated with visible light propagate along them from population to another one. The bridges could also contain ELF em waves serves as synchronizers in the time scale in which flickering occurs.

3. Bacteria absorb bio-photons from nutrition media in a way that the absorption is highest for some critical cell density [I67]. Female inbred daphnia in the same developmental stage and about the same size do not display the increasing bio-photon emission with increasing number [I67]. Rather, a typical interference pattern of emission is observed showing maxima and minima of the bio-photon intensity at definite average distances between the animals. This could be seen as evidence for the hypothesis that the pattern of coherent light from DNA serves as kind of hologram representing 4-D template for the self-organization.

2.8.3 General TGD Based Model For Coherent Bio-Photons

MEs with light like vacuum currents indeed generate coherent photons so that bio-photons indeed have a place in TGD Universe. ATP energy about .49 eV and near to the rough estimate .53 eV for the activation energy deduced by studying the temperature dependence of the delayed luminescence [I81]. This encourages to think that the MEs are closely related with the process transforming ADP to ATP serving as energy batteries (see [K53] for the TGD based model of ATP). This assumption conforms also with the fact that coherent light is associated with the oxidative process.

Bio-photons and MEs

The empirical data are consistent with the assumption that the MEs are associated with DNA (at least) and are perhaps responsible for the electromagnetic expression of the genetic information below cellular length scales (and corresponding scaled up dark length scales since there is no reason to exclude the dark variants of MEs).

MEs can carry Bose-Einstein condensates of parallel photons and the observed coherent photons represent leakage of the coherent light from cells. Both positive and negative energy MEs are possible and most naturally they are created in a pairwise manner: pairs (which do not form bound states) with a vanishing net energy and momenta are especially interesting since classical conservation laws do not pose any constraints on their creation and annihilation by p-adic-to-real transition. The buy now-pay later energy production by feeding negative energy to the environment might be closely related with the generation of pairs of MEs which vanishing net energy. It must be emphasized that also magnetic mirrors with positive and negative energies might be in question.

Bio-photons as a signature of dark matter hierarchy

Dark matter hierarchy allows perhaps the most plausible interpretation of bio-photons and is also in spirit with the general ideas about quantum holograms. The model of EEG (actually hierarchy of them) based on dark matter hierarchy [K38] assumes that the basic structures assignable to cell have fractal scaled up variants at higher levels of dark matter hierarchy. These higher level structures could generate dark photons with energies in the range corresponding to visible photons.

At the k_d^{th} level of the hierarchy predicted by Mersenne hypothesis the wavelength of photon is scaled up by a factor 2^{k_d} with possible values of k_d fixed by the Mersenne hypothesis [K38] so that communications using "visible dark" light become possible in arbitrarily long length scales. The model for cell membrane as a sensory receptor leads to the identification of these photons in terms of dark Josephson radiation and EEG and bio-photons have identification in terms of decay products of dark Josephson photons.

MEs would have lengths of order wave length (which are below cell size for visible light), and there would be a constant distribution of MEs with respect to the direction and length of ME in the scaled up length scale interval corresponding to wavelengths of visible light. The scaled up wavelengths would correspond to the distances between source and receiver of bio-photons and $k_d \equiv= 0$ would correspond to intracellular bio-photons assignable to MEs connecting sub-cellular structures having distance distribution which is more or less constant. The higher level contributions would tend to smooth out the wavelength distribution even if this is not strictly the case.

The general vision about quantum control of motor actions and sensory representations is consistent with the interpretation of positive energy MEs as space-time correlates for the emission of photons responsible for communications and negative energy MEs as correlates for phase conjugate photons involved with generalized motor control. In this framework bio-photons could result from the de-coherence of $k_d > 0$ dark photons and also as a leakage of $k_d = 0$ photons from cell interior. The synchronous flickering of dinoflagellates suggests $k_d > 0$ bio-photons are indeed present.

About the anatomy of dark MEs

MEs at the k_d^{th} level of dark matter hierarchy correspond to $r = 2^{k_d}$-fold covering of M^4, which are analogs of multi-sheeted Riemann surfaces (note that the meaning of "sheet" in this context is different from that in the context of many-sheeted space-time). Each sheet of the covering corresponds to scaled up variant of the space-time sheet associated with ordinary photon with r-fold size scale and classical energy E/r. This allows to interpret the formula $E = \hbar(k)f = r\hbar_0 f$ at space-time level.

r-fold MEs could be generated by r-sheeted magnetic flux sheets containing Bose-Einstein condensates of bosonic ions in quantum coherent manner such that each sheet is responsible for one sheet of r-fold ME.

The decay to ordinary photons can occur in two ways.

1. In de-coherence a downwards scaling of the structure by a factor $1/r$ and collapse to a single sheeted structure with energy E representing ordinary photon occurs. Since frequency is replaced with rf and $\hbar$ by $\hbar_0$, energy does not change.

2. The multi-sheeted structure could also decay to r single sheeted structures with energy E/r.

Constraint to the intensity of the vacuum current

The decomposition of dark MEs to r ordinary MEs cannot correspond to the generation of coherent photons by vacuum current since the frequencies involved would be much lower than the frequencies $\sim 10^{14}$ Hz associated with the visible light. Thus one can restrict the consideration to $k_d = 0$ case. This process might however also occur as the experimental findings of Gariaev [I27] about laser light induced radio-wave emission to be discussed in the next section indicate.

The source of photons at the second end of ME is responsible for the Bose-Einstein condensate of photons associated with ME. These photons are not observed unless some kind of leakage occurs at the receiving end of ME: suppose that this does not happen. Physical intuition suggests

that the light-like vacuum currents associated with MEs generate coherent states of ordinary photons and that these photons leak out and give rise to the observed bio-photons. MEs lose their energy in the process and become eventually vacuum extremals.

These assumptions allow to deduce a constraint to the intensity of the vacuum current associated with ME.

The interaction Lagrangian of the vacuum current with the vector potential of the quantized photon field is given by

$$L_{int} = e \int d^4x j \cdot A \tag{2.8.1}$$

where the indices of the second quantized vector potential and vacuum current have been dropped away for simplicity and the units $\hbar = c = 1$ are used and e denotes the electromagnetic coupling.

This interaction term describes an infinite number of harmonic oscillators coupled to an external oscillatory force. In each Fourier mode initial vacuum state is transformed to a coherent state which is an eigenstate of the corresponding annihilation operator. By standard calculations [B15] one can deduce the expression for the effective classical vector potential defined by the eigenvalues of the annihilation operators is given by

$$\begin{aligned} A(x,t) &= \frac{ie}{(2\pi)^3} \int d^3k \frac{1}{2\omega(k)} exp\left[-ik\cdot x - i\omega(k)t\right] j\left(k,\omega(k)\right) \quad , \\ \omega(k) &= |k| \quad . \end{aligned} \tag{2.8.2}$$

The eigenvalues $\alpha(\epsilon, k)$ for the annihilation operator $a(\epsilon, k)$ associated with polarization ϵ is given by the expression

$$\alpha(\epsilon,k) = \frac{ie}{2(2\pi)^3\omega(k)} \epsilon \cdot j(k,\omega(k)) \quad . \tag{2.8.3}$$

$\alpha(k)$ indeed has the dimension length to 3/2 as it should be on basis of the commutation relations in the continuous momentum basis. If finite quantization volume with a discrete momentum basis is used, $\alpha(k)$ contains additional $1/\sqrt{V}$ factor guaranteeing that the eigenvalues are dimensionless.

The eigenvalues characterizing the coherent states are proportional to the massless Fourier components of the vacuum current so that the intensities of bio-photons determining the values of the parameters $\alpha(k)$ allow to deduce the on mass shell Fourier components of the light like vacuum current. Of course, the coherent field of photons is superposition of several interfering contributions coming from MEs with light like currents and only the sum of these contributions appears in the detected field.

Sucking force in TGD framework

The mechanism by which sun flowers turn towards Sun as well as the attraction between cells are not very well well-understood processes. Popp and Chang introduce as an explanation an interaction which they call sucking force [I67]. The notion is inspired by the assumed analogy with the vacuum cleaner which is a particular kind of a pump. The pressure gradient along the tube of the vacuum cleaner generates airflow towards the tube. Since pumping is always done when dissipative processes are present, a process involving essentially the dynamics of quantum jumps is in question and the force does not have counterpart at the level of the irreversible classical dynamics.

In case of em fields radiation pressure gradient replaces the ordinary pressure gradient. The counterpart of the tube of vacuum cleaner is naturally a ME along which Bose-Einstein condensed photons propagate and are absorbed at the second end of the tube, most naturally cell in case of visible photons. The pumping implies an attractive force between living systems connected by MEs. This force would be present at all levels of the length scale hierarchy. The force is only between systems having common characteristic frequencies so that they can be connected by MEs.

For instance, this force could explain why tRNA carrying amino-acids finds the corresponding mRNA in the translation of DNA to proteins.

The sucked MEs can propagate along larger ME serving as an em bridge to the receiving system and the absorbtion most naturally corresponds to the annihilation with MEs of opposite energy. Both negative and positive energy MEs can be sucked. The sucking of negative energy MEs makes possible very flexible buy now-pay later type energy consumption: the user (say DNA) generates pairs of positive and negative energy MEs and utilizes the positive energy MEs, whereas the negative energy MEs are received by the payer, most naturally mitochondria where they annihilate with the positive energy MEs produced by ATP process.

2.8.4 The Interpretation Of Bio-Photons And EEG's Decay Products Of Dark Josephson Radiation

The foregoing considerations have been classical in the sense that MEs have been taken as a model for bio-photons. The model of EEG [K38] leads to the prediction that cell membranes act as Josephson junctions generating Josephson radiation. If the cell membrane is assumed to be almost vacuum extremal which brings in classical Z^0 field proportional to em field and raises the energy scale of Josephson junction from.07 eV for neuron to UV range. The electromagnetic charge of ion must be replaced with effective charge which is non-vanishing also for neutral atoms and molecules.

The energies of dark photons involved are in visible and UV range for most ions in the range of resting potentials just as the energies of bio-photons. The model also predicts correctly the peak frequencies of maximal sensitivity for the four kinds of photoreceptors. The frequencies are inversely proportional to the value of Planck constant characterizing the cell membrane. Quite generally, the value of Planck constant characterizes the evolutionary level of neuron.

Both EEG photons and bio-photons can be identified as decay products of dark Josephson photons producing either a bunch of EEG photons or single bio-photon. The frequency modulation of Josephson frequencies provides a general coding of sensory percepts and other information in terms of Josephson radiation communicating this data to the magnetic body. This modulation could also explain the observed periodic modulations.

2.9 Is it possible to reverse Alzheimer's disease?

Dale Bredesen has written a marvellous book titled "*The End of Alzheimer's*" [**?**] (see `http://tinyurl.com/ya8nkan9`) - thanks for my friend Pertti for an excellent Christmas gift.

Alzheimer's disease (just AD in the sequel) has been regarded as a disease without any effective treatment. A lot of progress has however occurred during last years in the understanding of AD and related diseases causing neuro-degeneration. Bredesen's group has developed a programme to stop and even reverse the development of cognitive decline and dementia.

2.9.1 Programme for reversing AD

The first chapter of the book contains a long list about the symptoms of AD. One must be cautious while reading this list. A strongly introvert and unpractical person like me having suffered from strong social fears during childhood, youth and mid age might conclude having been AD patient for all his life. Our personality however means that we have our strengths and weaknesses. Only if we begin to lose our strengths, there is a good reason to get worried.

AD involves brain inflammation causing a generation of amyloid, a plaque that destroys synaptic connections crucial for various learned skills. This leads to the symptoms of AD. Amyloids were for long time thought to be the cause of AD but it turned out to be only a way how brain defends itself: in AD this defence has only developed to over reaction: somewhat like too strong immune response causing allergy.

In an attempt to cure AD one can do three things (in collaboration with a professional since AD has strongly patient dependent profile).

1. Get rid of the brain inflammation.

2. Eliminate the sources of inflammation: both infection by microbes and sugar containing proteins.

3. Provide brain with the needed nutrients including metabolic energy, hormones, and trophic factors helping the regeneration of synapses.

   This program requires nothing less than changing of the life style.

2.9.2 AD as suicidal behavior at neuronal level

The motivation for this post emerged as I started to read a chapter about how the new view about AD developed through the study of AD in Petri dishes, a completely new lab level approach initiated by Bredesen's group. Two big surprises were in store.

1. It was found that in AD the neurons perform a suicide instead of fighting against the disease! They just give up! This was something totally unexpected.

2. The researchers had an idea that there are receptors in brain stem, which could relate to neuro-degeneration. The idea was that when the receptors bind to corresponding ligands, the neuron dies. It would be kind of organized suicide. But this did not occur! Neurons die if the ligand is not present! A healthy neuron must have both the ligands and receptors. These ligands can be christened as neurotrophins since they support the growth of cell.

2.9.3 Translating the findings about AD to the language of TGD

It is fascinating to translate the findings of Bredesen's group to the language of TGD. This might even provide new insights to what is involved.

Some basic notions of TGD inspired biology

While reading, I realized that this fits nicely with the TGD based vision that magnetic body (MB) of the organism (biological body (BB)) or part of it takes care of BB, such as brain by receiving information as signals from brain and sending back control commands. Before continuing it is good to briefly summarize some key aspects of TGD view about biology and brain. There are several new notions.

1. The notion of MB distinguishes between TGD and Maxwellian (gauge theory) view about fields. In many-sheeted space-time one can say that physical object has field identity, field body. Given for instance a magnetic flux tube realized as topological field quantum -tubular 3-surface - one can tell, which physical system it emanates from. The double formed by organism and its environment is replaced with a triple formed by MB , BB , and environment, and this changes profoundly the view about possible disorders of organism.

2. Hierarchy of Planck constants $h_{eff}/h = n$ making possible macroscopic quantum coherence in various scales is a key element of TGD inspired quantum biology. This hierarchy emerges as a prediction of adelic physics suggested to provide a unification of ordinary physics and of physics of cognition by introducing besides real number based physics also various p-adic physics serving as a correlate of cognition. $h_{eff}/h = n$ hierarchy and p-adic length scale hypothesis define fractal hierarchies of length and time scales: this fractality means that the standard length scale reductionism breaks down and that interesting new effects emerge in all scales. I have been identifying these effects for more than two decades now: the information flux from web has been indispensable in this task. Living matter would be one of the most striking deviations from the naïve reductionism. Even molecular physics and chemistry fail to reduce to atomic physics as the reductionistic dogma dictates.

   MB carries dark cyclotron condensates and dark photons with with non-standard value of $h_{eff}/h = n$. Cyclotron condensates and cyclotron radiation are crucial for the control of organism by its MB. The feed of metabolic energy generates cyclotron condensates.

3. The view about sensory perception and function of nerve pulse transmission differs from the standard view. Nerve pulse transition would not be communication between parts of CNS but building of communication line for dark photons making possible communications with maximal signal velocity [L33] [K79].

   (a) This would allow generation of sensory mental images at sensory organs by an iteration involving virtual sensory input from brain to sensory organs. Pattern recognition would be realized as a build-up of an artwork representing standardized mental image as near as possible to the original sensory input.

   (b) Neurotransmitters and all information molecules would be bridges needed to construct connected communication lines. Learning as formation of permanent synaptic connections would be generation of permanent bridges of this kind.

4. Cell membrane and perhaps also other structures serve as generalized Josephson junctions [K38]. The (generalized) Josephson radiation generated by nerve pulses would give rise to EEG (and perhaps also to its fractal counterparts) as communication of neural information from brain to MB via Josephson frequency modulation. The size scale of the layer of MB wold be rather large, of the order $1/f_c$, of the order Earth size in alpha band ($f_c \simeq 10$ Hz).

Disorders as problems in the communications between BB and MB and as problems at BB and MB

Both the failure of the communication and control links between magnetic body and problems at BB or MB can give rise to disorders/diseases. Many things can go wrong.

1. Magnetic flux tubes serve as kind of wave guides carrying signals consisting of dark photons. Telephone network gives an idea about the situation. The flux tube network would consists of permanently existing pieces, which can be connected to single connected communication line by attaching small bridges (relays) between disjoint flux tubes. This process is nothing attachment of information molecule (say neurotrophin ligand) to the receptor and thus serving as a bridge.

   If the connecting ligands are absent, the communication line does not exist and MB does not receive information from brain: MB cannot see its protege. Also the control of MB can fail if it involves this kind of bridges: MB becomes lame unable to help its protege.

   This is of course not the only mechanism. There might be ligands, which are competing for binding but not serving as relays so that the connection would not be built. This turns out to be the case in AP. The dynamical equilibrium between genuine bridges (trophins) and fake bridges (antitrophins) determines how much communication between MB and brain takes place. When fake bridges dominate, one has fully developed AP. This picture seems to be very general and apply also to a wide variety of other diseases, in particular Mad Cow disease.

   Could the blindness of MB with respect BB be the cause of A?! Could AD -and presumably many other diseases - be disorders in communications between BB and MB due to the broken communication lines? Does MB of brain as God of neurons purposefully reject some neurons? Sounds cruel but the limited metabolic resources could force to select between organism and individual neurons.

2. If MB is dynamical, some layers in its onion-like structure could even disappear. At the level of brain the structures of MB are indeed dynamical. The formation of mental image would involve the generation of connected quantum coherent flux tube network by the formation of bridges.

   Nerve pulse patterns would give rise to this kind of structure with neurotransmitters giving rise to small bridges between pre- and post-synaptic neurons. The formation of amyloid plaques would destroy the synaptic connections and destroy the MBs is the scale of brain.

   Remark: Watch-up network would serve as an analogy here.

3. The dark photons mediating the signal might fail to be generated at brain or at MB. Also depression involves brain inflammation. Depressive mood rather literally is characterized by a feeling of being rejected by God. MB has indeed forced to reject the patient if the signals from brain or to brain cannot propagate for some reason.

   Cyclotron radiation by biologically important ions would be needed to generate the dark photons needed in communications to and control from MB. EEG would be basic example of this kind of communications, which are however expected to be present in several frequency scales. Control commands could come via genome along flux sheets traversing DNA strand.

   Generalized Josephson radiation from neuronal membranes could mediate "sensory" information from brain to MB. The frequencies of generalized Josephson radiation are sums of differences $f_{0,in} - f_c out$ of cyclotron frequencies at the two sides of the neuronal membrane and genuine Josephson contribution $\Delta f = ZeV/h_{eff}$ coding for the nerve pulse patterns representing information as frequency modulation.

   At least the lack of Li and Mg are known to induce depression and suicide rates correlate with Li depletion. The cyclotron frequencies of Li_6 resp. Li_7 ions in the endogenous magnetic field $B_{end} = .2$ explaining the findings of Blackmann are 50 Hz (radiation at this frequency has biological effects) resp. 42 Hz (near thalamocortical resonance frequency) suggests that communications to MB suffer from Li depletion. Mg has cyclotron frequency 25 Hz (flash of light induces a response in dog's EEG at 25 Hz frequency).

4. Also control can fail. It is also possible that cyclotron condensates at MB are not generated so that MB cannot generate the dark cyclotron radiation driving the oscillators at biological body representing the control commands. This could be due to the lack of metabolic energy feed from BB to MB.

What AD actually is?

A further reading of the book taught more about what AD actually is.

1. It was found that peptide amyloid-beta (Aβ) is toxic to neurons acting as anti-trophin competing with trophin making possible the well-fare of neuron. The interpretation is in terms of competition between real and fake bridges. Since metabolic resources are finite, antitrophin can have healthy effect in many situations.

2. Amyloids was originally seen as the cause of AD. There exists so called dependence receptor known as amyloid precursor protein (APP): one might say that it monitors the state of neuron. There exists molecular scissors (proteases), which can split APP to either 2 peptides or 4 peptides.

   The members of peptide pair are inside and outside the cell membrane. They maintain the wellfare of the neuron. The 4 peptides divide two groups of 2 peptides inside outside of the membrane and include Aβ. Too high concentration of amyloid beta destroys synapses and leads to neuron death.

   Dynamical equilibrium between these two kinds of peptides determines the fate of the neuron. If the equilibrium shifts to the side of 4 bad peptides increasing their concentration, there is a risk that AD develops.

3. What determines the equilibrium between these two kinds of peptides? APP is a receptor than can bind to kinds of ligands, let us call them good and bad. The good ligand is known as netrin-1. In this case APP splits into to peptides supporting neuronal well-fare. Netrin-1 is trophin.

   Remark: Netrin comes from word "netr", which is sanskrit and means "one who guides". Netrin would indeed serve as a link to MB, which indeed guides!

   The bad ligand is Aβ! This leads to positive feedback. The higher the concentration of Aβ produced in splittings to 4 peptides is the faster the rate for the new similar splittings. This causes a catastrophe: an uncontrolled exponential growth of Aβ concentration analogous to cancer. Similar mechanisms appear also in cancer and Mad Cow disease. Peptides able to amplify their own concentration are known as prionic.

4. There are many causes of AP explaining why the usual single cause - single medication approaches to AD have failed. Bredesen's group as identified 36 independent causes of AD! One of these causes is APOE4. It was originally thought to reduce the clearance of amyloid from brain. This is true but it was also found to have much deeper role. It can affect gene expressing by binding to the promoter regions of DNA and preventing the transcription of genes coding for proteins promoting the well-fare of neuron. APOE4 is thus an active tool for inducing death of neuron.

5. Bredesen takes business organization in market economy as a metaphor. Brain must monitor whether the neurons are useful and whether metabolic and other resources are enough for survival. At older age these resources deplete. Brain must destroy the neutrons when there is shortage about nutrients, vitamins, hormones. Also neurons, which are inactive or somehow damage, must go.

TGD view about AD

The interpretation of this picture in TGD framework should be now rather obvious.

1. The simplest view is that netrin serves as a genuine bridge to MB and Aβ as the fake bridge. The dominance of fake bridges means that connection to MB is lost.

2. Brain must survive and decides to kill the neurons or force them to perform suicide, and uses APOE4 as one particular tool to realize this. MB would be innocent, so to say.

3. Or could MB serve as Stalin actively promoting neuronal death by activating mechanisms leading to neuronal death? Could the connections via the flux sheets of MB of DNA making possible control of BB allow this: is the activation of APOE4 preventing transcription of important genes related to this. One could argue that MB affects only DNA via promoter regions and APOE4 generated by brain itself prevents this. MB would not be Stalin after all.

4. Irrespective of who did it, in TGD Universe there is a hierarchy of selves and layers of MB serving as "Gods" and it includes also us. We can change our life style and prevent Alzheimer and many other diseases if we act early enough. We can do good deeds - also to our our biological bodies! Perhaps this is easier!

   Remark: This inspires the question whether same applies in capitalism/market economy, which is a fractal copy of biology at cell level in TGD Universe. We can transform biology to culture by bringing in ethics, values and moral.

Why Alzheimer does not destroy some aspects of consciousness?

Some aspects of consciousness seem to survive Alzheimer. Alzheimer patient can understand singing and also express himself by singing (see `http://tinyurl.com/y73zzrq4`). Why?

1. Singing is conventionally associated with holistic aspects of consciousness whereas language corresponds to reductionistic, local, and linear representation of conscious experience. Holistic-reductionistic dichotomy is often associated with right-left dichotomy. One should be of course cautious with this identification and be happy with holistic-reductionistic dichotomy.

2. In any case, we know that left brain talks and right brain sings. Singing is a representation in terms of frequencies. It is 2-dimensional because also the pitch matters unlike in the case of speech. Everyone familiar with Fourier transform knows that frequency representation is holistic: Fourier amplitude carries information about the function in the entire domain of definition but not about details for low enough frequencies such as occur in singing (maybe the duration of duration of nerve pulse of order millisecond could serve as standard, could notes with pitch below kHz frequency be low frequencies?).

3. Why cognition does not survive in Alzheimer is easy to understand. Cognition is by definition about details: left brain is responsible for language and language indeed local , *linear*(!), and reductionistic. Maybe 1-D neural strings and loops assignable to magnetic loops provide a

realization of spoken and written language? Alzheimer would destroy synaptic connections and would split these strings. The disappearence of even single bridge in the loop/string splits the loop/string (into two): this is just 1-D topology. Communication line would be broken. Cognitive skills and language would be lost.

4. Why would the holistic aspects of consciousness survive in Alzheimer? Suppose that right brain involves 2-D net-work like structures instead of 1-D neural strings having much more connections and giving rise to quantum tensor network [L26] (see `http://tinyurl.com/y9kwnqfa`) as it would be fashionable to say. Quantum entanglement is very probably involved and would be actually responsible for the holistic and hologram-like aspects of neural activities known for a long time. It would not be surprising if brain waves with frequency spectrum below kHz would be important for this representation. EEG waves are almost by definition in the range 1-100 Hz.

   What happens to 2-D networks in the destruction of synapes. Practically nothing! Quite a number of synaptic connections can disappear but this does not split the 2-D network into pieces as it splits 1-D string: 2-D topology! Communications take place and the structure can take care of itself. Holograms are not affected by the local splitting of the synaptic connections. The right brain would happily continue its singing!

   Note that 2-D networks are also natural for the representation of sensory data as images and the language of images is different from the language of words: I have discussed the differences between these two different languages in [L30] (see `http://tinyurl.com/yb99u6u8`).

   The natural question is whether could one approach to Alzheimer rely on activation of right brain: could art therapies such as music and visual arts help in Alzheimer?

Questions about memory

AD also inspires questions about memory. Neuroscientists often identify memories as skills. There are however memories such as sensory memories, which can be induced in any-one by electrical stimulation of temporal lobes. Also dreams involve these memories. One can have spontaneous memory of some smell or suffer pain in non-existing leg. Some people often regarded as cognitively impaired might have sensory memories regularly: this could explain their amazing memory feats. Some people hear music all the time in their head: Tchaikovsky is one example of this.

I find it difficult to believe that sensory memories would reduce to strengthening of synaptic connections in the brain now: they are not learned skills. In TGD picture the new view about time leads forced by zero energy ontology (ZEO) leads to the idea that the perceptive field is 4-D causal diamond (CD, 2-D visualization helps to understand) and that sensory memories are mental images (sub-CDs) located near either boundary of CD. The remaining mental images inside CD would be represented symbolically so that it would make sense to speak about "sensory now" in 3-D sense. Cognitive impairment would mean a loss of the symbolic representations and sensory representations might replace it and make memory feats possible.

Remark: In ZEO one can even make the scifi sounding question whether the brains of geometric past still in good shape could be used? There are people who have lost most of their brains but still can cope with challenges of everyday life.

Could this view be tested? Could Alzheimer patients have long term memories about time when brain was still healthy? Could they have sensory memories about that time? This might be the case: my grandmother lost her cognitive skills during her last years but re-lived her youth very intensely: she had even strong intention of going to dance!

2.9.4 Magnetite produced by traffic as a possible cause of Alzheimer disease

A rather unexpected partial explanation for Alzheimer's disease has been found: magnetite particles, which can be found in urban environments from exhaust gases containing breathing air [**?**] (see this). I have written earlier about Alzheimer's disease from the TGD point of view [K74]. Magnetite particles seem to be found in the hippocampus of those with the disease, which is central to memory. Now it has been found that the exposure of mice to magnetite leads to a generation

of Alzheimer disease. The overall important message to the decision makers is that the pollution caused by the traffic in urban environment could be an important cause of Alzheimer disease.

The brain needs metabolic energy. Hemoglobin is central to the supply of metabolic energy because it binds oxygen. Could it be thought that Alzheimer's is at least partially related to a lack of metabolic energy in the hippocampus? In the sequel I will consider this explanation in the TGD framework.

Short digression to TGD view of metabolism

Oxygen molecules O_2 bind to iron atoms in hemoglobin (see this) that already have a valence bond with 5 nitrogen atoms and a bond is created where Fe has received 5 electrons and a sixth from oxygen molecule O_2. So Fe behaves the opposite of what you would expect and hemoglobin is very unusual chemically!

Phosphate $O = PO_3$, or more precisely phosphate ion $O = P(O^-)_3$, which also plays a central role in metabolism, also breaks the rules: instead of accepting 3 valence electrons, it gives up 5 electrons to oxygen atoms.

Could the TGD view of quantum biology help to understand what is involved. Dark protons created by the Pollack effect provide a basic control tool of quantum biochemistry in TGD. Could they be involved now. Consider first the so-called high energy phosphate bond, which is one of the mysteries of biochemistry.

1. Why the electrons in the valence bonds prefer to be close to P in the phosphate ion? For phosphate one would expect just the opposite. The negative charge of 3 oxygens could explain why electrons tend to be nearer to P.

2. The TGD based view of metabolism allows to consider a new physics explanation in which $O = P(O^-)_3$ is actually a "dark" variant of neutral $O = P(OH)_3$ in which 3 protons of OH have become dark (in the TGD sense) by Pollack effect, which has kicked 3 protons to monopole flux tubes of the gravitational magnetic body of phosphate to such a large distance that the resulting dark OH looks like OH^-, that is negatively charged. Charge separation between the biological body and magnetic body would have occurred. This requires metabolic energy basically provided by the solar radiation. One could see the dark phosphate as a temporary metabolic energy storage and the energy would be liberated when ATP transforms to ADP.

Could this kind of model apply also to the Fe binding with 5 N atoms in haemoglobin by valence bonds such that, contrary to naive expectations, electrons tend to be closer to Fe than N atoms? Can one imagine a mechanism giving an effective negative charge to the N atoms or the heme protein and to O-O?

1. In this case there are no protons as in the case of phosphate ions. The water environment however contains protons and pH as a negative logarithm of the proton concentration measures their concentration. pH=7 corresponds to pure water in which H^+ and $(OH)^-$ concentrations are the same. The hint comes from the fact that small pH, which corresponds to a high proton concentration, is known to be favourable for the binding of oxygen to the heme group.

2. Could dark protons be involved and what is the relationship between dark proton fraction and pH? Could pH measure the concentration of dark protons as I have asked?

3. Could the transformation of ordinary protons to dark protons at the gravitational MB of the heme protein induce a negative charge due to OH_- ions associated with the heme protein and could this favour the transfer of electrons towards Fe? Could the second O of O-O form a hydrogen bond with H such that the proton of the hydrogen bond becomes dark and makes O effectively negatively charged?

What the effect of magnetite could be?

Magnetite particles, .5 micrometers in size, consist of Fe_3O_4 molecules containing iron and oxygen. According to Wikipedia, magnetite appears as crystals and obeys the chemical formula $Fe^{2+}(Fe^{3+})_2(O^{-2})_4$. The electronic configuration is $[Ar]3d^64s^2$ and 3 Fe ions have donated besides the s electrons also one electron to oxygen.

Could it happen that somehow the oxygen absorption capacity of hemoglobin would decrease, that the amount of hemoglobin would decrease, or that oxygen would bind to the magnetite molecules on the surface of the magnetite particle? For example, could you think that some of the O_2 molecules bind to Fe_3O_4 molecules instead of hemoglobin at the surface of the magnetite. Carbon monoxide is dangerous because it binds to the heme. Could it be that also the magnetite crystals do the same or rather could heme bind to them (thanks for Shamoon Ahmed for proposing this more reasonable looking option).

Chapter 3

Emotions as sensory percepts about the state of magnetic body?

3.1 Introduction

What emotions are? How emotions are created? How are they represented: in brains, at body, or perhaps somewhere else? One can consider these questions from the point of view of neuroscience, endocrinology, and quantum physics. Emotions can be divided to lower level emotions accompanied by intention/need/desire (hunger is accompanied by the need to eat) and thus distinguishing them from sensory qualia whereas higher level emotions like catharsis and the experience of beauty not accompanied by any desire. What does does this division correspond to?

TGD inspired answer to the questions is following.

1. Emotions are sensory percepts about the state of magnetic body (MB). Also sensory-motor loop generalizes: various glands excreting hormones to blood stream and binding to receptors give rise to the analog of motor output. Neural transmitters binding to receptors serve as bridges allowing to build connected networks of neurons from existing building bricks. They are accompanied by flux tube networks giving rise to tensor networks [L26] as quantum coherent entangled structures serving as correlates of mental images, and allowing classical signalling with light velocity using dark photons. In a similar way hormones would give rise to active networks of ordinary cells accompanied by tensor networks. Nervous system gives information about the state of these networks to brain and hypothalamus serves as the analog of motor cortex sending hormones controlling the excretion of hormones at lower level glands.

2. Emotions are sensory percepts about the state of magnetic body (MB) rather than those of biological body (BB). Also sensory-motor loop generalizes: various glands excreting hormones to blood stream and binding to receptors give rise to the analog of motor output.

   Consider first neuronal level. Neural transmitters binding to receptors serve as bridges allowing to build connected networks of neurons from existing building bricks (flux tubes associated with axons in the case of nervous system) and accompanied by flux tube networks giving rise to tensor networks as quantum coherent structures serving as correlates of mental images and allowing classical signalling with light velocity using dark photons. These tensor networks represent our mental images only if they correspond to our sub-selves [L41].

   In a similar way hormones would give rise to tensor networks of ordinary cells accompanied by flux tube networks giving rise to quantum coherent structures, tensor networks serving as correlates of emotional mental images. Nervous system mediates information about the state of these networks to brain. Hypothalamus serves as analog of motor cortex excreting hormones controlling the excretion of hormones at lower level glands.

3. The hierarchy of Planck constants defines a hierarchy of dark matters and $h_{eff} = n \times h$ defines a kind of IQ. The levels of MB corresponding to large/small values of n would correspond to higher/lower emotions.

MB decomposes to two basic parts: the part in the scale of BB and formed by networks having cells and larger structures as nodes (forming a fractal hierarchy) and the part in the scales larger than BB.

1. In the scales of BB (short scales) the dynamics involves topological dynamics of the flux tube network and sensory percepts can be accompanied by conscious-to-us desire to change the state of MB and thus of BB and could be seen as intentions induced by the comparison between what happened and what were the expectations. The outcome would be state function reduction replacing the behavioral pattern with a new one giving better hopes for achieving the goal. In zero energy ontology (ZEO) behavioral pattern is represented as quantum superposition of 4-D MBs so that time aspect is naturally involved with emotions.

2. In the scales larger than that of BB (long scales) the change the topology is not easy and the dynamics involves oscillations of MB - analogs of Alfwen waves - and analogs of ordinary motor actions changing the shape of flux tubes but leaving its topology unaffected (these actions might represent or serve as templates for ordinary motor actions in body scale [K99]).

   Alfwen waves with cyclotron frequencies and generalized Josephson frequencies assignable to cell membrane as Josephson junction [K79, K38] would be involved. The size scale of particular onion-like layer of MB corresponds to the wavelength scale for cyclotron frequencies and is proportional to $h_{eff}/h = n$ for dark photons. For instance, alpha band in EEG corresponds to the scale of Earth but the energy scale of dark photons is that of bio-photons.

   The TGD inspired model of music harmony [L15] gives as a side product a model of genetic code predicting correctly the numbers of codons coding for aminoacids for vertebrate code. The model allows to see sensory percepts about the dynamics in large scales as analog of music experience. The notes of 3-chords of the harmony correspond to light as dark photons and frequencies defining the notes of the chord: cyclotron radiation and generalized Josephson radiation from cell membrane would represent examples of dark light. Music expresses and creates emotions and music harmonies would correspond to various emotional states/moods realized at the level of DNA and its dark counterpart (dark nuclei represented as dark proton sequences). MB would be like a music instrument with flux tubes serving as strings. It is difficult to assign any specific desire to large scale sensory percepts about MB and the interpretation as higher emotions - or rather feelings - makes sense.

3.2 Background

3.2.1 Some background from evolution

It is good to list some basic data from evolution of nervous system (see `http://tinyurl.com/yabtfhy4`) first.

- Bacteria have no nervous system but already they are capable of simple sensory perceptions. Bacteria can move to the direction where the concentration of nutrients increases so that they probably perceive the concentration of nutrients. The feelings of hunger and satiety are perhaps the most primitive emotional states, one can think that these emotions/feelings were possessed also by bacteria. The need to get food is associated with hunger and it seems that the lower emotions induce desire/intention leading to goal directed behavior.

- Ladder-like nervous system is a primitive nervous system possessed by invertebrates and has at its end a bulge - ganglion - representing primitive brain. Anthropods, which include insects, belong to this class of animals.

- Brainstem and cerebellum developed from the ganglion and gave rise to what is called lizard brain. Brain stem controls the functioning of heart, lungs, stomach and other organs and cerebellum controls motor activities. Since the cortex allowing to decompose visual field into objects is missing, vision must be very primitive - including however detection of motion and distance for the target of attention. Maybe there is just the target of attention instead of the decomposition of the perceptive field into objects. Olfaction, hearing, and vision work together to identify the target of attention.

- Chordata (see http://tinyurl.com/63af3ag) consist of urochordata and cephalochordata preceding vertebrates.

  Remark: Vertebrates have EEG, which must be a significant difference. In TGD framework scaled up variants of EEG are in principle with higher frequency ranges are possible with similar structure and correspond to smaller value of $h_{eff}/h = n$.

- Limbic system (see http://tinyurl.com/ny2e8ff) defines what is known as emotional brain. It contains hypothalamus as an analog for the highest motor areas in cortex. Hormone excretion is the tool of control. Using this tool hypothalamus controls the hormone excretion of lower level glands in brain and body in turn controlling the state of body. Hormone levels correlate strongly with emotions [**?**].

- At the top is cortex containing sensory, motor and associative regions.

3.2.2 Some background from neuroscience and endocrinology

Also some data bits in neuroscience and endocrinology dealing with the endocrine system, its diseases, and its specific secretions known as hormones are in order. Endocrine system forms only part of cell signalling (see http://tinyurl.com/yckwaaob). One can classify the signalling according to the range of signals. Intracrine signals stay in target cells, autocrine signals affect the cell itself or of nearby cells via receptors. Juxtacrine signals affect adjacent (touching) cells. Paracrine signals target cells in the vicinity of the cell: nerve pulses correspond to this kind of signalling. Endocrine signals target distance cells and hormones reaching their target via blood stream serve as signal molecules.

Remark: In TGD framework the term "signal molecule" is misleading. Signal molecules bound to receptors would only serve as bridges/relays giving rise to networks in which dark photon signals would propagate and make possible classical communications. Also quantum entangled structures - tensor networks - would be formed.

1. Limbic brain (see http://tinyurl.com/ny2e8ff) would be the neural part for the system behind emotions and serve as the analog of cortex participating the neural processing related to emotions. Neural information would arrive from body to brain via nervous system and the analog of motor response from limbic brain would be based on endocrine system using hormones as a control tool (http://tinyurl.com/l2pstuv) .

2. Endocrine system (see http://tinyurl.com/l2pstuv) involves several feedback loops via hypothalamus and pituitary. Hypothalamus plays a role analogous to that of the highest motor areas in cortex. Emotions are expressed via excretion of hormones by hypothalamus (see http://tinyurl.com/hdt5t8g) and the hormones from hypothalamus control the excretion of hormones by lower level glands. Besides hypothalamus also pituitary gland and pineal gland are brain glands.

   The four most important glands outside brain are pancreas, ovaries/testes, thyroid gland, parathyroid gland, and adrenal glands: together with 3 brain glands this makes altogether 7 glands. Interestingly, this happens to be the number of chakras in the Eastern medicine. Besides this there are many other hormone secreting organs. The so called diffuse endocrine system involves hormone emitting cells heart muscle and epithelial cells in gut. Immune system excretes hormone and also skin can be regarded as a gland.

3. Hormones (http://tinyurl.com/znk4tzn) are used to communications between organs and tissues for physiological regulation and behavioral activities. Hormones have diverse chemical structures, most of which belong to 3 classes: eicosanoids, steroids, and amino acid/protein derivatives (amines, peptides, and proteins).

   All vertebrates possess hypothalamus (see http://tinyurl.com/hdt5t8g). Hypothalamus is located below thalamus and serves as a link between neural system and endocrine system and regulates certain metabolic processes and other activities of the autonomic nervous system. Hypothalamus synthesizes and releases neural hormones in turn stimulating or inhibiting the secretion of pituitary hormones in turn controlling the secretion of hormons in lower level glands.

Hypothalamus controls body temperature, hunger, important aspects of parenting and attachment behaviors, fatigue, sleep and circadian rhythms. Hypothalamus consists of several nuclei. Hypothalamic-pituitary-adrenal axis is a complex set of direct influences and feedback between hypothalamus, pituitary and adrenal glands located in kidneys. Delta waves (in EEG) with frequencies in the range (.5,4) Hz - usually thought to arise either in cortex or thalamus - controls extretion of neural hormones from hypothalamus.

Remark: In TGD framework delta waves would be associated to the control by MB. Note that delta waves do not correlate directly with the contents of consciousness.

Endocrine system controls physiology and there are good reasons to think that at least some hormones are closely related to the control of simple emotions such as satiety, pleasure, hunger, fatigue, fear, aggression, and rage. Not all emotions involved need to be conscious to us. For instance, at the neural side autonomous part of the neural system is unconscious to us.

Remark: TGD inspired theory of consciousness [L41] predicts self hierarchy. The sub-selves of self give rise to mental images of self. Sub-sub-...-selves contribute a diffuse background to the experience of self. Emotions could correspond to this kind of background.

The book "Molecules of emotion" by Candace Pert [**?**] gives a nice representation about peptides as molecules of emotions. Dopamine is one peptide acting both as both neural transmitter and hormone and positive emotions accompany its excretion.

3.2.3 What emotions are and how do they emerge?

Basic facts about emotions

One learns from Wikipedia (see `http://tinyurl.com/7ml7vcs`) that there is almost endless variety of theories of emotion. For instance, in Scherer's components processing model of emotion, five crucial elements of emotion are said to exist:

- Cognitive appraisal: provides an evaluation of events and objects.
- Bodily symptoms: the physiological component of emotional experience.
- Action tendencies: a motivational component for the preparation and direction of motor responses.
- Expression: facial and vocal expression almost always accompanies an emotional state to communicate reaction and intention of actions.
- Feelings: the subjective experience of emotional state once it has occurred.

This definition of emotion includes as its aspects cognitive processing (neural feedback), physiological correlates (hormone excretion), action tendencies (intentions/needs/desires/drives), bodily expression of emotion, and feeling. This classification assigns physiological activation patterns to all emotions (what about "higher" emotions?). Feeling forms only one aspect of emotion.

It has been also proposed that there are 6 basic emotions: anger, disgust, fear, happiness, sadness and surprise. One can wonder why pleasure and psychological pain are not counted as basic emotions: maybe they are associated with happiness and sadness. Neither hunger and satiety are included: since hunger induces goal directed behavior, it would seem natural to count it as emotion rather than sensory experience. It seems possible to assign to emotions positive/negative coloring, which would allow to see them as pairs analogous to pairs of color and complementary color.

Personally I would call emotions inducing desires primitive emotions perhaps possessed already by the simplest organisms - even those without a nervous system. Certainly I would not try to reduce higher level emotions such as experience of beauty to these primitive emotions.

One can also distinguish emotions using as a criterion the time scale involved: feelings, moods, temperament, personality describe these time scales in increasing order.

1. Primitive emotions represent information in a very concise form. Just a single bit represented as emotional coloring of experience as positive or negative is enough and if it is

negative/positive it induces an intention to change/continue the behavior. A very complex unconscious information processing can give rise to this bit and intuition and emotional intellect could summarize the outcome of this kind of processing.

Remark: In TGD framework this unconscious information processing could be assigned to the levels of self hierarchy below sub-selves identified as mental images.

2. It seems that simple emotions induce the need or desire to do something, an intention. This would naturally relate to the comparison of the expected state to the perceived one. If the result is not expected, the desire to change something is created: hunger $\rightarrow$ need to eat. Computer scientist would tend to see us as collection of behavioral programs (habits and routines) and emotional coloring would suggest how to change the routine to possibly achieve the desired result.

3. Low level emotions are holistic meaning that the physiological correlates cannot be localized in particular body part. One might however argue that a person fallen in love localizes this feeling with heart. Also hunger (if counted as emotion rather than sensory experience) can be localized to stomach. In any case, emotions as mental images would be holistic and physiologically assignable to a rather large part of body. One can argue that higher level emotions such as feeling of beauty cannot be localized to body.

4. There are also experiences what one might call higher level emotions and they perhaps relate to emotional intellect and intuition. They can be created in by many ways: say by art: catharsis - experience of beauty - or by meditation - experience of bliss. It is difficult to associated this kind experiences with particular physiological events. Interestingly these emotions do not seem to induce any desire or intention.

   Music creates this kind of emotions. Simplest emotions are feeling of joy and sadness correlating with the harmony of music but in general music harmony defies characterization in terms of language and in terms of emotions of real life. To my opinion this correlation is a valuable guide line as one tries to understand correlates of emotions and feelings.

Are emotions percepts or analogs of motor actions?

Concerning the generation of emotions there has been debate between proponents of two alternative visions.

1. Brain expresses emotions using body as a tool so that emotions (e-motion) would be analogous to motor activities. The problem is that emotions are not intentional actions and one cannot control them. The explanation could be that the activities generating emotions are unconscious to us. This argument might make sense: we have autonomic nervous system too.

   Remark: In TGD framework self hierarchy could solve the problem. An action unconscious would be conscious at some lower level of the self hierarchy. Emotions would be our perceptions about what has happened at lower levels of self hierarchy and the outcome would be statistical.

   This view is supported by the existence of endocrine system. Glands excreting hormones would generate the emotions as analogs of motor actions. Hormones diffuse via blood circulation and induce emotional expression. Hormones serve as molecules of emotion and information. Hypothalamus plays the role of the highest motor area controlling by hormones the hormone expression of lower glands.

   Hypothalamus, pituitary, and pineal gland are brain glands. The glands in body can can also control emotions. In particular, heart muscles and epithelial cells in gut could independently express emotions by emitting hormones. Reflex action serves as an analogy for this.

2. Philosopher James proposed an alternative interpretation: body produces emotions and brain perceives them: this would explain why emotions are not under volitional control. This interpretation as such has been show to be wrong by an experiment in which the generation of physiological correlate of emotion was prevented in gut: the emotion was however felt.

It is however true that there is neural feedback giving information about the physiological state.

Candace Pert proposes in her book [?] a compromize between these views. There is the analog of sensory-motor loop involved and one cannot actually say that emotion would be associated with brain or with body: it is assignable to both of them.

Remark: Quite recent observation (see `http://tinyurl.com/pzfhw9d`) is that so called vagus nerve traverses all organs and couples nervous system, endocrine system, and immune system together. In TGD picture this nerve would build bridges between neurons of these systems and couple them to single quantum coherent system and allows communications with dark light between these organs.

3.3 TGD based interpretation for emotions

In TGD framework the interpretation of the transmitters involved (such as hormones) would not be as signal but as a tool creating the channels making signals propagating with light velocity (dark photons transforming to ordinary photons identified as bio-photons) and giving rise to quantum coherent active networks of cells (tensor networks) giving rise to conscious entities at some level of self hierarchy and possibly our mental images as sub-selves.

Signal molecules bound to receptors would act as small bridges connecting existing pieces of network to larger networks. These pieces would be flux tubes associated with axons in the case of nerve pulse transmission and neurotransmitters would give rise to the bridges. Synchronous neuronal firing would be a signature of the connected flux tube network. In [L33] and [L31] TGD inspired view about nervous system is discussed. This view has a natural generalization to the case of other signalling systems.

The dynamics for the topology (reconnections, braiding) of MB would induce the dynamics of biomolecules, cells and larger structures at the nodes of the fractal network.

3.3.1 Basic notions of TGD inspired quantum biology

It is good to list the basic notions of TGD inspired biology once again. They are magnetic body (MB), dark matter as $h_{eff} = n \times h$ phases of ordinary matter with n having non-standard value having first principle description in terms of adelic physics [L39], and zero energy ontology (ZEO).

1. The basic distinction between TGD and Maxwell's electrodynamics and gauge theories is that every system as field identity in TGD Universe as separate space-time sheets, topological field quanta correspond to magnetic flux sheets or tubes and also to electric field has topological quanta. This follows from the notion of 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 forces the replacement organism + environment $\rightarrow$ magnetic body (MB) + organism + environment. MB receives sensory input from biological body (BB) and controls BB. 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 [L21]).

2. 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 measures the complexity of the algebraic extension associated with the dynamics as dimension of extension of rationals involved with the dynamics at basic level, and serves as a kind of IQ. Evolution corresponds to a gradual and unavoidable increase of $h_{eff}/h = n$ in statistical sense.

   (a) At the atomic level the value of n seems to be $n = 6$ rather than $n = 1$ [L34, L27]. For valence bonds the value of n is already larger and increases along the rows of the

periodic table being largest for the molecules containg atoms toards the right end of the period: biologically important atoms C, N, O, S, P are examples associated with valence bonds with large n.

(b) 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.

(c) An important additional hypothesis generalizes the notion of gravitational Planck constant due to Nottale [E2]. The hypothesis [K31, K32, K33, K34, K72] states that at the flux tubes mediating gravitational interactions (propagation of gravitons) one has

$$\hbar_{eff} = n\hbar = \hbar_{gr} = \frac{GMm}{v_0} \ ,$$

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.

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).

The value of M depend 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}.

3. Zero energy ontology (ZEO) essential for TGD inspired theory of consciousness is the third basic notion. In ZEO quantum states have as classical correlates 4-D space-time surfaces rather than time=constant snapshots of time evolution as in standard physics. They can be identified as preferred extremals of action principle analogous to Bohr orbits. Following biologists and neuroscientists one could speak about the generalization of the notion of behavioral pattern or biological function. Computer scientist talks about programs.

   The act of free will is analogous to a replacement of a deterministic program with a new one in ZEO. 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.

   System must have sensory percepts about the state of MB. If the percept is not consistent with the expectation, the perception is accompanied by negative emotional coloring.

3.3.2 Sensory perceptions as artworks

TGD view about neural system differs in several aspects from that of neuroscience.

1. Sensory organs are assumed to serve as carriers of sensory percepts: qualia [K45] are not associated with sensory areas but with sensory organs [L30, L33]. ZEO providing a new view about time and memory allows to solve the basic objection related to phantom limb

phenomenon: pain in phantom limb would be sensory memory and realized as 4-D sensory percept having contributions from geometric past.

2. The distinction between experienced time - identified as a sequence of small state function reduction identifiable as analogs of weak measurements (generalized Zeno effect) - and geometric time identifiable as distance between the tips of causal diamond (CD) is essential for understanding this view about memory [K7].

3. The assumption that sensory percepts are artworks rather than passive records of sensory input requires virtual sensory input from brain to sensory organs and build-up of the final standardized percept by pattern recognition - an iterative procedure involving very many forth-and back signals. Nerve pulse transmission is quite too slow process to allow this and dark photon signals propagating with maximal signal velocity between brain and sensory organs are suggestive [L33]. Dark photons decay to ordinary photons in energy conserving manner and identifiable as bio-photons and having energy spectrum in visible and UV range [K13, L11].

4. Nerve pulses and neurotransmitters would not represent real communication but give rise to temporary intra-brain communication lines along which communications as dark photon signals would take place with maximal signal velocity using dark photons (characterized by $h_{eff}/h = n$) transforming to biophotons in an energy conserving manner. Neurotransmitters and also other information molecules (hormones,..., messengers) attached to receptors would serve as bridges fusing permanent but disjoint communication lines along axons to a connected temporary communication line for dark photons to propagate. Nerve pulses would also generate generalized Josephson radiation allowing communications between biological body (BB) and magnetic body (MB) using EEG. Meridian system would be permanently connected system of communication lines.

5. This picture leads to a concrete proposal [L30, L33] about the roles of DMT and pineal gland concerning imagination and dreams and hallucinations. Pineal gland would indeed serve as third eye (it serves quite concretely as an eye in some lower organisms) but receives dark photon radiation from MB. This give rise to imagined sensory percepts. DMT attaching to the receptors can lead to continuation of flux tubes down to sensory organs and this in turn would generate sensory percepts identifiable as dreams, hallucinations, psychedelic experiences, mystic experience, even encounters with extraterrestrial life-forms.

3.3.3 Emotions as sensory percepts about the state of MB

The model of emotions relies on the identification of sensations as sensory percepts about the state of magnetic body so that the same mechanisms would be involved. In particular, the percepts at the level of brain would involve iterative fourth-and-back signalling using dark photons building emotions as standardized mental images.

Consider first the view about sensory perceptions and motor actions.

1. One can argue that ordinary sensory percepts are basically observations about the state of BB. For instance, retina is part of body affected by the incoming light signal. Nerve pulses from sensory organs generate transmitters, which produce bridges connecting existing flux tubes to connected flux tube networks assignable to networks of active neurons. The activity manifests as synchronous firing. This makes possible communications with light-velocity and quantum entanglement for the network possible so that it become tensor network [L26]. These network give rise to sensory mental images representing objects of the external world.

   Remark: Cortex is essential for this process: this would mean that organisms without cortex should not be able to decompose perceptive field to objects. Is midbrain able to achieve targeted attention to some feature of perceptive field and how much does the information processing in retina contribute? Note that frogs have no cortex and are able to perceive only the motion of the target and presumably also its distance.

2. Motor action can be seen as a response to sensory percept. In ZEO motor action has interpretation as time reversed sensory perception mathematically. This is suggested by Libet's

classical discovery [**?**] that the decision to perform motor action is preceded by neural activity in brain. TGD based interpretation is that the decision induces a classical signal proceeding to geometric past or that it replaces superposition of space-time surfaces with a new one so that the "average" geometric past changes.

This view generalizes to emotions.

1. Emotions would be seen as sensory percepts about the state of MB rather than that of BB. For the part of MB inside BB the topology of MB is under continual change and lower level emotions would characterize the state of this part of MB. Not all these emotions need be conscious to us and this might relate to diffuse de-localized character of emotions. The most important contribution to the bodily emotion would come from the dynamical pattern for the topology of MB regarded as 4-D object in ZEO.

   Also now emotional mental images would be assignable to MB and would naturally be artworks involving forth-and-back signalling with light-velocity.

2. Hormones as molecules of emotion excreted to blood flow as an analog of motor response would replace neural transmitters and serve as bridges allowing to build networks of cells and possibly larger structures. Hormones would serve as tools for changing the topology of the network in body length scales and the topology would depend on the distribution of hormones. One would have the analog of sensory-motor loop involving feedback in terms of neural signals.

   Hypothalamus would serve in the role of motor area in cortex and control other glands by excreting hormones controlling their hormone excretion. The neural input to brain and eventually to limbic brain would lead to the hormonal response of hypothalamus and other glands. Also MB would control the response.

   As already noticed, delta waves in frequency range [.5,4] Hz (not correlating directly with our conscious experience) are involved with the control the excretion of hormones from hypothalamus. Neuroscientist would assign these waves to cortex and thalamus, In TGD framework these waves would come from appropriate layer of MB but could have also brain counterparts since the interaction between MB and BB requires resonance and therefore same frequencies [L42].

3. The connected networks of cells - or more precisely, their 4-D time evolutions as space-time surfaces analogous to Bohr orbits - would give rise to emotional mental images. The 4-D nature of basic objects could explain why emotions involve temporal aspect. Their size scale of networks would be typically rather large so that emotions or more precisely feelings associated with them would be holistic and would not allow localization to any part of body. In smaller scales they would be probably unconscious to us: this could provide an alternative explanation for the diffuse nature of emotions. Besides transmitters and hormones there are also other information molecules responsible for the generation of tensor networks inside cell and in the vicinity of cells.

4. There are also sensory percepts from the part of MB outside BB. There are no nodes defined by cells or larger structures of organism and the dynamics could involve motions of biological body perhaps representing this dynamics as a template or mimicry.

   Remark: Since the magnetic bodies of organisms can have sizes of order Earth size and even larger different organisms - in particular those of the same species - could appear as nodes of flux tube network. This might related to the findings of Sheldrake [I71, I72] about species learning [L22].

   Also oscillations of this part of MB - analogs of Alfwen waves (see `http://tinyurl.com/7ekxqt2`) propagating with light velocity and analogous to oscillations of strings in the case of flux tubes - should contribute to sensory percepts about MB. EEG and its possibly existing fractal counterparts at higher frequency scales have natural identification as the analogs of Alfwen waves and cyclotron frequencies are favoured frequencies in the control of gene expression by MB as also their differences modulated by nerve pulse patterns in the case of communication of sensory data from cell membrane to MB [K79]. These oscillations could

correspond to higher emotions since these parts of MB have the largest values of $h_{eff}/h = n$. In feelings generated by music time is indeed essentially involved and one can say that these experiences are non-local in time.

It would seem that emotions, which do not involve any obvious goal or desire - such as happiness or sadness - correspond to higher level emotions assignable to the part of MB outside MB. Note that the parasympathetic part of autonomic system - rest-and-digest mood - involves also goals/needs/desires such as sexual arousal, salivation, lacrimition, urination, digestion, and defecation so that these emotions do not correspond to "higher" ones. The sympathetic part - fight-or-flight mood - obviously involves desires and goals.

Remark: One of the basic paradoxes related to time is how it possible to become conscious of entire music piece in single moment as for instance Mozart did. The explanation relies on the distinction between subjective time and geometric time.

The idea the part of MB with the scale of BB stores emotional memories raises interesting questions. Could also immune system involve flux tube network? Could the meridian system of Chinese medicine (see `http://tinyurl.com/cwwggkw`) be a flux tube network having acupuncture points as nodes. Is this network rather static and based solely on signalling with dark photons? The reports that heart transplants can transfer the memories of the donor to the receiver conform with the proposed vision. The claim that eating meat causes violent nightmares is supported also by my own experiences.

3.3.4 Emotions and information

It is known that emotions correlate strongly with information although emotions and rational thinking are often seen as diametrically opposite to each other. One however speaks of intuitive feelings and emotional intelligence is now a generally accepted notion.

1. Negentropy is a measure for the amount of conscious information having no counterpart in standard physics, where one can define only ensemble entropy and entanglement entropy. Entanglement negentropy is defined in p-adic sectors of the adele and although it obeys generalization of Shannon formula it can have positive values unlike the negative of the ordinary Shannon entropy.

   Remark: Adelic physics [L39] [L38] fuses real number based physics for sensory experiences (physics of matter) and various p-adic physics as physics of cognition to single structure.

2. The values of $h_{eff}/h = n$ for given system is bound to increase in statistical sense since there exists infinite number of extensions with dimension higher than given extension and only finite number of them with dimension smaller. The increase of n does not imply increase of negentropy: it only gives prerequisites for generating larger negentropy and the system can decide whether to do this.

3. Metabolic energy feed provides system with molecules having valence bonds with values of n larger than for atoms. Hydrogen bonds and their generalization have even larger n. To gravitational flux tubes one can assign even larger n. Reality as zero energy state wants to understand itself and this leads to an increase of its negentropy in statistical sense and at the same time makes reality algebraically more complex giving rise to evolution in this manner. Note that metabolic energy does not generate negentropy as I have claimed earlier - it only makes possible to generate negentropy.

Emotions - at least those assigned to BB in the proposed model - have positive/negative coloring. What could be the interpretation of this bit.

1. Could this bit tell whether the state function reduction meaning a replacement of zero energy states as a kind of behavioral pattern with new one led to increase or decrease of negentropy?

2. Or could the color of emotion tell whether the state function reduction led to the increase or decrease of n characterizing the ability to generate negentropy.

3.3.5 "Higher" emotions and music

Music expresses emotions and also create higher level emotions. As all art, it also induces experience of beauty. Since $h_{eff}/h = n$ serves as a kind of IQ in the evolutionary hierarchy, there are good reasons to expect that the emotions/feelings induced by music and other art forms are assignable to MB.

The dynamics of MB involves oscillations characterized by frequencies and in EEG frequencies are of key importance for the part of MB outside biological body. The communications from cell membrane to MB involve modulation of EEG frequencies identified as generalized Josephson frequencies by nerve pulse patterns [K79] and would define a coding of sensory data to higher level emotions. The control signals from MB via DNA inducing gene expression would use dark photons at cyclotron frequencies to control BB.

Model for music harmonies and genetic code

For few years ago I ended up with a model of music harmonies leading also to a model of genetic code as a side product [L15].

1. The idea was that the 12-note scale could allow mapping to a closed path (octave equivalence) going through all vertices of icosahedron having 12 vertices and not intersecting itself. Also the idea that the triangles defining the faces of the icosahedron have interpretation as 3-chords defining the notion of harmony for a given chord deserves study. The paths in question are known as Hamiltonian cycles and there are 1024 of them [A3]. There paths can be classified topologically by the numbers of triangles containing 0, 1, or 2 edges belonging to the cycle representing the scale. Each topology corresponds to particular notion of harmony and there are several topological equivalence classes.

2. In the article [L18] I introduced the notion of Hamiltonian cycle as a mathematical model for musical harmony and also proposed a connection with biology: motivations came from two observations. The number of icosahedral vertices is 12 and corresponds to the number of notes in 12-note system and the number of triangular faces of icosahedron is 20, the number of amino-acids. This led to a group theoretical model of vertebrate genetic code and replacement of icosahedron with tetra-icosahedron to explain also the 21st and 22nd amino-acid and solve the problem of simplest model due to the fact that the required Hamilton's cycle does not exist. The outcome was the notion of bio-harmony.

3. All icosahedral Hamilton cycles with symmetries (Z_6,Z_4, Z_2^{rot} and $Z_2 refl$ turned out to define harmonies consistent with the genetic code. In particular, it turned out that the symmetries of the Hamiltonian cycles allow to to predict the basic numbers of the genetic code and its extension to include also 21st and 22nd amino-acids Pyl and Sec: there are actually two alternative codes - maybe DNA and its conjugate are talking different dialects! One also ends up with a proposal for what harmony is leading to non-trivial predictions both at DNA and amino-acid level.

4. The conjecture is that DNA codons correspond to 3-chords perhaps realized in terms of dark photons - music of light - or even ordinary sound. 256 different bio-harmonies are predicted and these harmonies would give additional degrees of freedom not reducing to biochemistry. Music expresses and creates emotions and a natural conjecture is that these bio-harmonies are correlates of emotions/moods at bio-molecular level serving as building bricks of more complex moods. Representations of codons as chords with frequencies realized as those of dark photons and also sound is what suggests itself naturally. This together with adelic physics involving hierarchy of algebraic extensions of rationals would explain the mysterious looking connection between rational numbers defined by ratios of frequencies with emotions.

5. In fact, also the emotions generated by other art forms could be realized using music of dark light. Dark photons in various wavelength ranges and correspond to various values of h_{eff} would correspond to various sensory qualia and are represented at pineal gland ("third eye") as imagined sensory percepts [L33]. They can be transformed to real sensory percepts at sensory organs by using DMT molecules as bridges allowing the propagation of dark

photons (or the bio-photons resulting in their energy conserving transformation to ordinary photons) to sensory organs, where they generate genuine sensory experience identified as dream, psychedelic experience, hallucination, etc...

How to realize emotions as music of genes concretely?

How to realize the music of genes represented as sequences of 3-chords of dark light as a communication tool between dark and ordinary DNA/RNA and possibly even dark and ordinary variants of tRNA and amino-acids?

1. Communication between ordinary and dark matter levels must be possible. This is guaranteed if the transition energy spectra at different levels of $h_{eff}/h = n$ hierarchy contain common transition energies so that a resonant interaction by exchange of dark photons becomes possible. This condition is extremely demanding and could explain why basic bio-molecules are selected amongst numerous alternatives [L42] - this is indeed one of the hen-egg problems of pre-biotic evolution.

2. A hypothesis worth of studying is that the cyclotron transition energies of both ordinary DNA and RNA nucleotides and their dark variants represented as dark proton sequences are same [L42]. Cyclotron transition energies should cover several octaves and the natural proposal is that magnetic field strength associated with the flux tube codes for the notes. In music experience roughly 10 octaves are needed corresponding to the range of audible sounds.

3. The cyclotron frequencies of DNA nucleotides A, T, C, G are very nearly the same and near 1 Hz for $B = B_{end} = .2$ Gauss since their masses do not differ much. Since the nucleotides are negatively charged, also the cyclotron energies for codons and codon sequences are around 1 Hz. $h_{eff} = h_{gr}$ hypothesis states that the cyclotron energies of DNA are in the energy range of bio-photons in visible and UV.

There should be correspondences between a) the 64 ordinary DNA codons and allowed 3-chords and b) 64 dark variants of DNA codons and allowed 3-chords. These correspondences fix that between ordinary and dark codons. One would have triality.

1. To realize music of genes one the value of B must have values in a range of several octaves. The magnetic field strengths B associated with the flux tubes accompanying DNA strand should have a spectrum given by 12-note scale. Both 64 dark DNA codons and $4^3 = 64$ ordinary DNA codons should correspond to $20 + 20 + 20 + 4 = 64$ allowed 3-chords formed from the notes of 12-note scale.

2. Dark codons correspond to entangled states of 3 dark protons. The positions of dark protons are different so that ermutations of the positions of dark protons are involved. The invariance of 3-chord under permutations of notes would correspond to fermionic statistics. These permutations are lifted to braidings if dark protons are connected by flux tubes to some other system, for instance ordinary DNA.

   If the dark protons are ordered linearly along flux tube, it would seem that these these positions correspond to those of ordinary code letters. This does not make sense. If the letters of codon are connected to the dark protons by flux tubes, the permutations of dark codons induce braiding of the flux tubes but do not affect the order of the letters of the ordinary codon. Braiding would become an essential part of the correspondence between ordinary and dark codons.

3. One should understand the correspondence of dark codons with the allowed 3-chords of a given harmony and also with the ordinary DNA codons. Bio-harmony is defined as a composite of 3 harmonies with 20 allowed 3-chords and having symmetries Z_6, Z_4, and Z_2 and of tetrahedral harmony with 4 chords. Tetrahedron can be regarded as disjoint object or attached to DNA, and this gives two variants of code.

   How could these the icosa-tetra-hedral Hamilton cycles relate to the physical realization of dark proton triplets? Each icosahedral cycle should give rise to 20 dark proton triplets. Why

the icosahedral geometry with Hamiltonian cycle should make itself manifest in the quantum physics of dark proton triplet?

4. Could icosahedral geometry quite concretely correspond to a tensor network? The vertices of the icosahedron would be connected by a sequence of flux tubes connecting nearest neighbors to form a Hamiltonian cycle. Dark proton triplets would quite concretely be localized at the triangular faces of the icosahedron.

   Braided triplet of flux tubes would emerge from the vertices of an icosahedral triangle defining 3-chord and would connect it to the nucleotides of the corresponding ordinary DNA codon. Magnetic field strengths at these flux tubes would correspond to the notes of 12-note scale as defined by the Hamiltonian cycle in question. The permutations of the dark proton states at the vertices of the triangle would induce braidings of the flux tube triplet actually defining minimal braid in topological quantum computation (sic!) The braiding accompanying the states of 3 dark protons would make the correspondence with ordinary ordered DNA codons possible.

   Note that each dark proton triplet could be also connected (without braiding) to its conjugate dark proton triplet by a triplet of flux tubes so that one would obtain closed flux loops and one could speak of knots instead of braids.

   Remark: Braiding brings strongly in mind the many TGD inspired proposals for DNA as topological quantum computer [K2, K108]: maybe DNA as topological quantum computer could be (also?) realized in this manner.

   What physical objects could the 20 vertices of icosahedron correspond to? Hydrogen bonded water clusters give rise to both tetrahedral and icosahedral structures. Could one associate dark proton triplets to the dark parts of these structures? Could one try to experimentally identity possible sequence of icosahedral water molecule clusters with vertices connected by hydrogen bonds associated with the DNA sequence? If the hydrogen bonds correspond to flux loops as suggested, they can be rather long (proportional to $h_{eff}/h = n$) so that even distant water molecules can become hydrogen bonds and one could have a fractal hierarchy of icosahedra.

5. Resonance condition suggests that at the level of ordinary DNA double strand the cyclotron energies of dark protons associated with the hydrogen bonds connecting DNA nucleotides correspond to those of flux tube triplets connecting ordinary and dark DNA codons. The magnetic field strengths associated with the dark flux tubes accompanying hydrogen bonds would correspond to those associated with the triangles of icosahedral triangle. This would make possible communication between the two dark sectors by dark-photon triplets as music of genes.

This leaves unanswered questions.

1. Why the 20+20+20=60 3-chords from 3 harmonies with different icosahedral symmetries (Z_6, Z_4, Z_2) and 4 chords from tetrahedral harmony would combine to form single bio-harmony with 64 chords? This requires the presence of 3 Hamiltonian cycles with different symmetries. Why all three different symmetry types for DNA and RNA? Could the 20 amino-acids correspond to single symmetry type? Could tRNA codons correspond to two symmetry types?

2. How the 3-chords of dark photons could be played? 3-chord should be a collective effect affecting both dark and ordinary codon by inducing emission of 3-photon state like - like playing a chord by string instrument. The notes of the light chord need not emerge simultaneously but as arpeggios. Could there be a pulse travelling along the Hamiltonian cycle and picking all the cyclotron notes at the vertices containing dark proton and sending a cyclotron signal along flux tubes to ordinary DNA codon. This pulse would travel along dark DNA and play the music defined by dark DNA sequence.

3.3.6 Support for the view that information molecules serve as bridges in flux tube networks

I have discussed information molecules from TGD point of view for for the first time about two decades ago [K70]. It was amusing to find that this discussion highlighting the interpretational problems related to information molecules is still very topical. These strange findings give direct support for the view that information molecules serve as bridges making possible the formation of networks of cells interpreted in terms of flux tube networks in TGD framework. For this reason I glue below the earlier discussion followed by the recent comments.

> *Central nervous system (CNS), endocrine system and immune system are three basic systems involved with bio-control and -communication. The work of Candace Pert and other neuroscientists has led to a general notion of information molecule described in popular manner by Candace Pert [**?**]. Neural transmitters and modulators associated with CNS are only special cases of information molecules. Also neuropeptides and various hormones are involved. It has become clear that emotions are closely related with the activity of information molecules and that both brain, endocrine system and immune system communicate intensively with each other. One could regard even brain as a big gland. Of course, one could also consider various glands and organs as mini-brains.*
>
> *The interactions of the information molecules involve the formation of receptor-information molecule complex either at cell surface or in the cell plasma inside cell. Receptor-information molecule complex inside cell can move to genome and induce gene transcription. In case that the complex is formed at the surface of cell, second messenger action is involved. One can also speak about N:th messenger action. There are many poorly understood aspects related to the mechanisms of information molecule action [I57].*
>
> 1. *There are only few second messenger pathways and relatively few receptors but large number of different functions. This phenomenon is known as pleiotropy or multi-functionality. For instance, given second messenger causes different effects depending on the hormone that activated it (the phenomenon is somewhat analogous to the phenomenon in which message can be understood in several ways depending on the state of receiver). At purely chemical level the problem is how second messenger knows what hormone activated it? In steroid action the complex formed by information molecule and receptor in turn activates some gene. Now the question is: How the activated RNA polymerase knows which gene has to be activated? Pleiotropy appears also at level of hormones. Same hormone can have multiple effects and the border between hormone, neuropeptide or even neurotransmitter is unclear. For instance, hormone which by definition transmits long distance communications, can have effects in nearby cells and thus acts like a neuropeptide. How hormone knows what function it must perform? Also drugs and treatments can have different effects and side effects.*
>
> 2. *There is also functional redundancy: the same function is performed by several second messenger molecules. For instance, glucagon, growth hormone, adrenaline and corticosteroids elevate glucose levels. This suggests that there is deeper level of communication involved and that second messenger molecules are more like computer passwords than subprogram calls. Now the question is: What these subprogram calls do correspond physically?*
>
> 3. *Biological functions can be initiated also in non-chemical manner. The phenomena of healing by touch and the effects of meditation and biofeedback are examples of biological self-organization processes are initiated in non-chemical manner. Even other treatments like massage, acupuncture or meditation can decrease or inhibit pain. These observations suggest that chemical level is not the deepest level involved with biological functions and the question is: What is this deeper control level?*

Simple lock and key mechanism cannot provide answer to the questions raised above. Rather, computer password might provide better metaphor for the second messenger action whereas receptor-information molecule complex would effectively generate subprogram call perhaps carried by the second messenger molecule or possibly broadcasted. It seems that information molecules act more like signs or symbols rather than being purely chemical agents. These symbols are interpreted by cell level intelligences and the interpretation depends on context.

The mysterious looking finding is that the cell activated by information molecules somehow knows, which information molecule did the activation. This can be understood if the information molecule attached to the receptor serves as a bridge so that the cell becomes part of a flux tube network to which information molecule characterizes. The recent interpretation is in terms of a generation of a flux tube network. Information molecule characterizes the network which is formed. The information storage capacity of these networks - allowing quantum entanglement - is exponentially large than that of state of the nodes: hence the naïve AI based idea about copying consciousness to diskette by assigning a bit to each neuron is extremely unrealistic.

3.3.7 Getting memories by eating those who already have them

While writing this article I learned about extremely interesting findings. I have already earlier written about the finding that both pieces of a split planaria inherit the memories (identified as learned skills or conditionings) of the original planaria [K75]. One possibility is that the bodies rather than brains of the planaria carry the memories. Second possibility is that the splitting of planaria involves the replication of its magnetic body carrying at least some of the memories. The news at this time was that planaria get the memories of planaria that they have eaten!

To begin with, one must carefully distinguish between genuine memories and memories as behavioral patterns (conditionings, skills).

1. Cognitive memories as behavioral patterns are assumed to be due to the strengthening of synaptic contacts (long term potentiation (LPT, see `http://tinyurl.com/yafzovyk`) giving rise to nerve circuits, which are active or easily activated.

   In TGD framework activation means formation of a flux tube network giving rise to quantum entangled state with neurons at the nodes: neural activity generates transmitters serving as bridges between flux tubes associated with axons and create flux tube network carrying a conscious mental image. A quantum coherent entangled tensor network is formed and also classical communications using dark photons are possible in this state. These neurons are firing synchronously. Nerve pulses would not be signals between neurons but would induce communications to magnetic body in scales even larger than body.

2. Genuine memories - say episodal memories - would in TGD (zero energy ontology, ZEO) correspond to neural activities in geometric past: kind of seeing in time direction. These are typically verbal memories but also sensory memories are possible and can be induced by electric stimulation of brain.

Consider now the experiments discussed in the popular article "*Somewhere in the brain is a storage device for memories*" (see `http://tinyurl.com/y8ejpcho`). They all relate to the identification of memory as a behavioral pattern induced by conditioning and are therefore emotional memories.

1. In one experiment sea slugs learned to avoid painful stimulus. This led to a generation of synaptic contacts between neutrons involving increased synaptic strength - long term potentiation (LPT). Then some drug was used to destroy the LPT. The problem was that the lost contacts were not those formed when the memory was formed!

2. In second experiment mice were used. A conditioned fear (LPT) was induced in mice and again the generation of synaptic contacts was observed. Then the contacts - long term potentiation - was destroyed completely. Memories as conditioned fear however remained!

It was an amusing accident to learn about this just when I was building a model for emotions as sensory percepts about the state of magnetic body (MB) fundamental in TGD inspired quantum biology.

1. In the recent case the memories are definitely emotional memories and in TGD framework they would be naturally at the level of body and generated as mental images associated with large numbers of ordinary cells appearing as nodes of quantum entangled flux tube networks giving rise to tensor networks [L26]. Hormones would be the tool to generate and modify these networks.

2. Emotional memories would be represented by the conditioning and analog of LPT at the level of body rather than at the level of brain! Hormones like also other information molecules would act as relays connecting existing pieces of network to larger ones! The neural activity would be involved only with the generation of memories and induce hypothalamus to generate the fear network using the hormones controlling hormonal activities of lower level glands.

3. The model could also explain the finding that in the splitting of flatworm the both new flatworms inherit the memories and that even non-trained flatworms eating trained flatworms get their memories (defined as behavioral patterns involving emotional conditioning).

3.3.8 How brain selectively remembers new places?

Emotions are involved with memory storage and memory recall. Limbic brain, in particular hippocampus, plays a key role in these processes but what really happens is not really understood. The notion of memory has two basic meanings. Memory can mean learned skills and emotional conditionings: one can argue that memory is not correct word in this case. Long term potentiation (LPT) strengthening synaptic contacts is known to be the key mechanism in the formation of memories in this sense. Memory can also mean memory recall: what happens in genuine memory is not understood and it is difficult to understand episodal memories in terms of conditioning and synaptic contacts.

In TGD framework one might say that LPT makes possible generation of cognitive (emotional) mental images as quantum entangled flux tube networks and also signalling using dark photons between neutrons (cells) of the network. In TGD framework memory recall means seeing in time direction making possible to retrieve information about the mental images in the geometric past and even to re-experience them.

There was a very interesting link in Minding Brain (see `http://tinyurl.com/y8w2zyus`) related to the storage of new memories. The title of the popular article (see `http://tinyurl.com/yap3dzuk`) is "*How brain selectively remembers new places?*". The research article by the research group led by Nobelist Susumu Tonegava is published in PNAS [**?**] (see `http://tinyurl.com/yak262hu`). The following represents TGD based view about what might happen.

1. In TGD framework brain/body corresponds to 4-D geometric object classically - a space-time surface with complex topology (zero energy ontology, ZEO). Brain and biological body are accompanied by magnetic body (MB) defining a topological time evolution of flux tube network having neurons (and also body cells) as its nodes and it is MB, which seems to be of fundamental significance [L33, L48] (see `http://tinyurl.com/y8mpo7mb`) and `http://tinyurl.com/ydhxen4g`). Memories are located in 4-D brain (body) for the first time to the time-place, where they were formed, later successful memory recalls form new copies of them.

2. To remember is to see in time direction to geometric past. The signal sent from hippocampus backwards in geometric time scatters back in standard time direction: this is nothing but seeing in 4 dimensions. 4-D memory storage means that there is practically no limitations on memory storage since new storage capacity is created all the geometric time! Making careful distinction between experienced and geometric times allows to both avoid paradoxes and solve the paradoxes of existing theory.

   Remark: Also the possibility of quantum entanglement also increases exponentially the memory storage capacity (and destroys the dreams of AI afficionados about copying human consciousness as bits telling whether neuron fires or not to a computer file!).

3. Brain is able to detect whether the sensory percept - say completely new place - is indeed new. Brain acts as novelty detector. This requires scanning of 4-D brain to see whether there are sensory percepts in geometric past, which share common features with the recent sensory percept. This requires high level conceptualization so that perceptive field is decomposed to objects with some attributes. If common objects are not found, the percept is regarded as something new. In this case a new symbolic memory representation about perceptive field is formed.

4. This strongly suggests that the signal sent from hippocampus scatters back from brain of past and is then compared with the recent sensory percept. If they the signals are very similar - this might give rise to some kind of resonance - the experience is "I have seen this before". The information provided by the already existing memory is utilized. If not then sensory percept is regarded as new and memory representation is formed.

Where is this new memory representation constructed?

1. The article suggests that locus coeruleus (LC) and area CA3 of hippocampus are involved. It was found that the modulation of CA3 by LC is was involved in the formation of new memory: if the modulation was prevented, no new memory was formed and the mice behaved next day as if the place were still new.

2. In ZEO the new memory would correspond to a collection of activated neurons in LC and CA3 accompanied by connected flux tube structure represented the new mental image as a quantum entangled structure - tensor network. This kind of mental images would have formed for some period of time in the brain of the mice and given rise to a 4-D representation of new place to be read later by sending signals backwards in geometric time.

3.4 The experiments of Masaru Emoto with emotional imprinting of water

Sini Kunnas sent a link to a video telling about experiments of Masaru Emoto (see `http://tinyurl.com/pqy57jj`) with water, which is at criticality with respect to freezing and then frozen. Emoto reports is that words expressing emotions are transmitted to water: positive emotions tend to generate beautiful crystal structures and negative emotions ugly ones. Also music and even pictures are claimed to have similar effects. Emoto has also carried out similar experiments with rice in water. Rice subjected to words began to ferment and water subject to words expressing negative emotions began to rotten.

Remark: Fermentation is a metabolic process consuming sugar in absence of oxygen. Metabolism is a basic signature of life so that at least in this aspect the water+rice system would become alive. The words expressing positive emotions or even music would serve as a signal "waking up" the system.

One could define genuine skeptic as a person who challenges existing beliefs and pseudo-skeptic (PS in the sequel) as a person challenging - usually denying - everything challenging the mainstream beliefs. The reception of the claims of Emoto is a representative example about the extremely hostile reactions of PSs as aggressive watchdogs of materialistic science towards anything that challenges their belief system. The psychology behind this attitude is same as behind religious and political fanatism.

I must emphasize that I see myself as a thinker and regard myself as a skeptic in the old-fashioned sense of the word challenging the prevailing world view rather than phenomena challenging the prevailing world view. I do not want to be classified as believer or non-believer. The fact is that if TGD inspired theory of consciousness and quantum biology describes reality, a revolution in the world view is unavoidable. Therefore it is natural to consider the working hypothesis that the effects are real and see what the TGD based explanation for them could be.

The Wikipedia article about Masaru Emoto (see `http://tinyurl.com/pqy57jj`) provides a good summary of the experiments of Emoto and provides a lot of links so that I will give here only a brief sketch. According to the article Emoto believed that water was a "blueprint for our reality" and that emotional "energies" and "vibrations" could change the physical structure of

water. The water crystallization experiments of Emoto consisted of exposing water in glasses to different words, pictures or music, and then freezing and examining the aesthetic properties of the resulting crystals with microscopic photography. Emoto made the claim that water exposed to positive speech and thoughts would result in visually "pleasing" crystals being formed when that water was frozen, and that negative intention would yield "ugly" crystal formations.

In 2008, Emoto and collaborators published and article titled "Double-Blind Test of the Effects of Distant Intention on Water Crystal Formation" about his about experiments with water in the Journal of Scientific Exploration, a peer reviewed scientific journal of the Society for Scientific Explorations (see `http://tinyurl.com/ycsnu2oc`). The work was performed by Masaru Emoto and Takashige Kizu of Emoto's own IHM General Institute, along with Dean Radin and Nancy Lund of the Institute of Noetic Sciences, which is on Stephen Barrett's Quackwatch (see `http://tinyurl.com/y99kol2e`) blacklist of questionable organizations. PSs are the modern jesuits and for jesuits the end justifies the means.

Emoto has also carried experiments with rice samples in water. There are 3 samples. First sample "hears" words with positive emotional meaning, second sample words with negative emotional meaning, and the third sample serving as a control sample. Emoto reports (see `https://youtu.be/Wc-ZmvxfBxE`) that the rice subjected to words with positive emotional content began to ferment whereas water subject to words expressing negative emotions began to rotten. The control sample also began to rotten but not so fast.

In the sequel I will consider the working hypothesis that the effects are real, and develop an explanation based on TGD inspired quantum biology [K101, K75, K74]. The basic ingredients of the model are following: magnetic body (MB) carrying dark matter as $h_{eff}/h = n$ phases of ordinary matter; communications between MB and biological body (BB) using dark photons able to transform to ordinary photons identifiable as bio-photons; the special properties of water explained in TGD framework by assuming dark component of water implying that criticality for freezing involves also quantum criticality, and the realization of genetic code and counterparts of the basic bio-molecules as dark proton sequences and as 3-chords consisting of light or sound providing a universal language allowing universal manner to express emotions in terms of bio-harmony realized as music of light or sound. The entanglement of water sample and the subject person (with MBs included) realized as flux tube connections would give rise to a larger conscious entity expressing emotions via language realized in terms of basic biomolecules in a universal manner by utilizing genetic code realized in terms of both dark proton sequences and music of light of light and sound.

3.4.1 The reception of the findings of Emoto

The findings of Emoto challenge the materialistic world view and have received both genuine criticism and "criticism".

Criticism and "criticism"

Commentators have criticized Emoto for insufficient experimental controls and for not sharing enough details of his approach with the scientific community. Prof. emeritus William A. Tiller, a researcher featured in the documentary "*What The Bleep Do We Know?*", states that experiments of Emoto fall short of proof, since they do not control for other factors in the supercooling of water. It is easy to agree that scientific proof is not in question. William Tiller claims that supercooling of water involved with the experiments might have delicate effects difficult to control.

Remark: Supercooling of water makes it critical system, even quantum critical and in TGD Universe, and this makes it ideal target of remote mental interactions.

A lot of experiments are needed: in particular, the possible dependence on the person who utters the words with emotional content, deserves to be studied. Just taking randomly chosen group of people and control system might not be enough to achieve a significant effect. Situation could be similar to that in the recent double slit experiments of Radin [L29] (see `http://tinyurl.com/y72b87p7`), in which subject person tries to intentionally affect the interference pattern for light travelling through slits. The effect is clear in the case of experienced meditators. That very few of us are not concert pianists, cannot be used to argue that there are no concert pianists.

There is also the authoritative "criticism", which carefully avoids stating anything about contents of the work and directs the efforts on rhetoric tricks. These "criticisms" do not deserve serious attention except as perfect examples of the empty rhetorics so typical for PSs. The following examples are citations from the Wikipedia article (see `http://tinyurl.com/pqy57jj`).

> Emoto has been criticized for designing his experiments in ways that leave them prone to manipulation or human error influencing the findings. Biochemist and Director of Microscopy at University College Cork William Reville wrote, "*It is very unlikely that there is any reality behind claims of Emoto.*". Reville noted the lack of scientific publication and pointed out that anyone who could demonstrate such a phenomenon would become immediately famous and probably wealthy.

Remark:The absence of scientific publication (in respected journal of course) often reflects the fact that PSs have reached their goal to prevent publishing anything challenging their beliefs. I have experienced this myself during four decades very concretely. At nineties it became even impossible to get anything into arXiv.

> Writing about Emoto's ideas in the Skeptical Inquirer, physician Harriet A. Hall concluded that it was "*hard to see how anyone could mistake it for science*". Commenting on Emoto's ideas about clearing water polluted by algae, biologist Tyler Volk stated, "*What he is saying has nothing to do with science as I know it.*" Stephen Kiesling wrote in Spirituality & Health Magazine, "*Perhaps Emoto is an evangelist who values the message of his images more than the particulars of science; nevertheless, this spiritual teacher might focus his future practice less on gratitude and more on honesty.*".
>
> Needless to restate that these comment say nothing about contents.

Emoto is not the only victim of pseudo-skepticism

The criticism of the experiments of Emoto mostly reflects the prevailing materialistic dogmas, which do not allow these effects so that depending on the authority Emoto is concluded to be mad, charlatan, or evangelist. The rage of PSs is really frightening and demonstrates how powerful effects ideology can have.

Emoto shares the fate of experimenters studying water memory and homeopathy. "Homeopathy" is indeed a word making skeptic growl and drool: one can hardly imagine a more impressive demonstration of words on water than this! An almost- Nobelist Benveniste was labelled as swindler as he announced about experiments providing support for water memory and homeopathy. Magician Randi - Randi again(!) - participated the investigation of the mind-police of science, in which Benveniste and laboratory staff was treated like criminals unless otherwise proven.

There is a lot of support about the representation of water memory as extremely low frequencies (ELF) of radiation associated with water [I23, I24]. These ELF frequencies can be stored electronically and they produce the same effects as the bio-active chemical, whose presence induced these frequencies in water. These facts PSs simply neglect because they do not fit the belief system of PSs dating back to 18th century. At the age of IT the idea about the existence of representations of bio-active molecules as frequency patterns able to induce the biological effects of molecules without the presence of molecules should not raise aggressions.

Few years ago HIV Nobelist Montagnier did experiments giving support for water memory and the procedure involved a part very similar to that used in preparing homeopathic remedies [I34] [L5]. In TGD framework these frequencies wuold correspond to cyclotron frequencies assignable to MBs of molecules, and immune system is proposed to have emerged from the ability of water to mimic the magnetic bodies of invader molecules and learning to recognize them [K49]. This interpretation could mean a breakthrough in biology but unfortunately the time is not mature for this yet.

Remote mental interactions/paranormal phenomena [K101] belong also to the pariah phenomena having no place in materialistic world and people having the courage to challenge this view are labelled as science criminals by PSs.

Analyzing the mindset of PS

People calling themselves skeptics are rarely skeptics in the original meaning of the word but believers, even fanatic believers. The basic un-challengeable belief is materialism stating that consciousness is only an epiphenomenon - illusion as David Dennett puts it without explaining what he means with the claim that consciousness does not exist but is only one particular phenomenon of consciousness - namely illusion. There is no free will and there are no genuine intentional actions. Moral and ethics are illusions. And certainly, human can have no intentional effects on water since even genuine intentional effects on our own body are impossible. This leads to the notion of objectivity as PS understands it.

This notion of objectivity implies that the outcome of given experiment cannot depend on who carries it or on who the subject persons are. If this turns out to not be the case, the experiment is not well-done and experimenter can be ridiculed. Water is dead matter for PS, even the PS himself should be dead matter if the materialistic logic is taken to its bitter end. I dare guess that most PSs privately believe - without even realizing that this is the case - that their intentions genuinely affect the sack of water with some chemicals that is called their body. It is extremely difficult pretend that one is not conscious when one is conscious.

The conclusion of the PS is that the outcome of Emoto's experiments with water and rice cannot depend at all on the person who utters the words expressing positive or negative emotions. PS calls this assumption objectivity but is actually only an assumption that there is no such thing as intentional free will and that we live in a deterministic world of billiard balls. This view is known to be wrong: quantum entanglement has been verified for cell sized system in macroscopic scales and quantum world is non-deterministic - mentioning this fact is carefully avoided in text books. PSs also unashamedly put under the rug hundreds of anomalies related to the physics of water.

If human intention and emotion can have effects on water, the first question is whether the intention and emotion of some humans these effects are stronger. Belief moves mountains and since Emoto believes that intention can have effects, it would be only natural that the effects are stronger. If this is true, one cannot demand the repeatability of the experiment anymore. In paranormal research the experimenter effect is well-known - some experimenters are more successful than others without being charlatans - as also in medicine. This is the case always when living systems are involved. There is another amusing example demonstrating the shallowness of the thinking of PSs: PSs love to say that the effects of healing practices produce nothing but placebo effects without realizing that placebo effect as such is a fascinating mind-over-matter effect begging for explanation!

Of course, if Emoto believed that the emotions have effects on water, his desire to prove this belief might have produced these effects - not by cheating but by intentional rather than emotional imprinting based on remote mental interactions affecting water. The words as such need not have caused the effect. This would represent an example of remote mental interactions. Note however that also music and even pictures were reported to have effects on water and it is not easy to explain this as experimenter effect.

An amusing "experiment" on rice was carried out by a hard-nosed skeptic Carry Poppy (see `http://tinyurl.com/y8g9jgal`). The extremely nasty tone of the article reveals the hatred of Poppy towards Emoto and people challenging the materialist world view. The outcome of the "experiment" carried by Poppy was of course negative. Perhaps not surprising, the outcome would express faithfully the real intention and desire of the experimenter!

3.4.2 TGD based model for Emoto's findings

In TGD based view the notion of magnetic body (MB) is central [K75, K74]. MB carries dark phases of matter identified as phases of ordinary matter with $h_{eff}/h = n$ making possible macroscopic quantum coherence explaining the coherence of living matter not understandable in the biochemistry based approach. The interactions between MB and biological body (BB) are essential remote mental interactions based on signalling using dark photons. Therefore the basic mechanisms of quantum biology would be also mechanisms of remote mental interactions - only the target would be non-standard. We are mostly water and it would not be surprising if these mechanisms would allow intentional and emotional imprinting of also water outside our body and

in quantum critical state.

Basic incredients of the model

In TGD universe water is very special substance in that it contains both ordinary water and its dark variant. What makes it dark is that dark magnetic flux tubes representing long hydrogen bonds are present for some portion of water [L50] (see `http://tinyurl.com/y8fvwbp9`): the length of bonds scales as n or perhaps even n^2. The presence of these flux tubes makes any liquid phase a network like structure and one ends up with a model explaining an anomaly of thermodynamics of liquids at criticality known already in Maxwell's time. This leads to a model explaining the numerous anomalies of water in terms of the dark matter.

For instance, the dark part of water with non-standard Planck constant transforms to ordinary water in freezing. As a consequence, a large amount of energy is liberated. This explains why water has anomalously large latent heat of fusion. One can also understand why the volume of water increases in freezing and decreases in heating in the interval 0-4 °C. The anomalies of water are largest at physiological temperature $T_{phys} \sim 37$ °C suggesting that the dark portion of water is largest at T_{phys}. Dark fraction of water would be essential for life.

Dark protons sequences at flux tubes representing genetic code and the analogs of basic biomolecules are realized in water. Pollack effect [L16] (see `http://tinyurl.com/oyhstc2`) requiring feed of energy - as IR radiation for instance - generates so called exclusion zones (EZs), which are negatively charged regions. A fraction of protons from water must go somewhere and the TGD inspired proposal [L16] (see `http://tinyurl.com/gwasd8o`) is that the protons transform to dark protons at magnetic flux tubes. The dark variants of particles quite generally have higher energies than ordinary ones and energy feed provides the needed metabolic energy go make the protons dark. In the case of homeopathy and water memory mechanical agitation creates provides the metabolic energy and would generate EZs accompanied by dark proton sequencies at flux tubes [K49].

Remote expression of emotions as crystal patterns - emotional imprinting - is required and communication requires a code so that receiver and sender have same interpretation for the signal. Genetic code would provide the fundamental code making possible universal meanings. TGD leads to two basic proposals predicting the numbers of DNA codons coding for given AA rather successfully.

1. The first proposal [L21] relies on TGD view about dark matter as $h_{eff}/h = n$ phases of ordinary matter [K40, K31, K32, K33, K34, K72] motivated by adelic physics extending physics to include also the correlates of cognition [L39, L38] (see `http://tinyurl.com/ycbhse5c` and `http://tinyurl.com/ybzkfevz`). The empirical motivation comes from several sources, in particular from the findings of Pollack.

   Dark genetic code would be realized in terms of dark proton sequences at flux tubes- dark nuclei. The model predicts dark counterparts of DNA, mRNA, tRNA, and AA as dark proton sequences which codons identifiable as dark proton triplets. Bio-chemistry would emerge as a shadow of the much simpler dynamics of dark matter at flux tubes and genetic code would be induced by dark code code.

2. Second model of genetic code emerged accidentally from a geometric model of music harmony [L15, L49] (see `http://tinyurl.com/yad4tqwl` and `http://tinyurl.com/yd8d8x6j`) involving icosahedral (12 vertices-12-note scale and 20 faces-number of AAs) and tetrahedral geometries leading to the proposal that DNA codons and possibly also AAs correspond to 3-chords defining the harmony and obtained as unions of 20+20+20 3-chords associated with icosahedral 20-chord harmonies with symmetries Z_6, Z_4, Z_2 plus tetrahedral 4-chord harmony. There is large number of these harmonies bringing in additional degrees of freedom.

   Remark: This model has obviously analogies with the notion of wave genome introduced by Peter Gariaev [I26, I27, I51].

   Since music both expresses and creates emotions, the proposal is that these harmonies assigning additional hidden degrees of freedom to the MBs of dark variants of DNA, RNA, etc... serve as correlates of emotions also at the molecular level. This emotional context could also give rise to context dependence of the code if several harmonies are realizable chemically.

Taking seriously TGD inspired theory of consciousness [L41] (see `http://tinyurl.com/ycxm2tpd`) and model of emotions [L48] (see `http://tinyurl.com/ydhxen4g`), one might say that the details of the code might depend slightly on the "emotional" state of DNA, RNA, and possibly other molecules.

TGD based mechanism for emotional imprinting

One must not forget that as a passionate researcher Emoto probably had very intimate relationship with water! As we all have with one particular water volume, which we call our body! I can intend raising my hand and it raises. Also my emotions are expressed in this personal bag of water containing also some fraction of biomolecules. I doubt that even the most fanatic PS would not try to tell me that I am performing a sleight of hand as I do this. But they should do this in order to take their materialistic logic to its bitter end.

One can perhaps say that Emoto extended his body by fusing with the MB of water, which in turn controls the ordinary part of water just like it controls our own body. The reports of experiences about extension of body are not unheard in the spiritual practices. Not even in everyday life. If you touch ground with a stick, you experience the touch as if the stick were part of your body. Could the stick really become part of your body in some sense?

What could be the precise mechanism for emotional imprinting (as analog of intentional imprinting that Tiller talks about [**?**])?

1. The basic vision is that living matter is a quantum critical system making it extremely sensitive to perturbations (actually TGD Universe is quantum critical in well-defined sense [L51] (see `http://tinyurl.com/yakzlllk`). This makes biological system an ideal sensor and motor instrument. In particular, intentions can affect body water at quantum criticality optimally. At quantum criticality phases with several values of Planck constant $h_{eff}/h = n$ are present and correspond to dark matter which is the key player in TGD inspired model of living systems. As already noticed, the dark portion of water would be maximal at physiological temperature.

2. In the system studied by Emoto the subject person and water must form an entangled quantum critical system. Water - or rather, the MB of water - must have part of it in $h_{eff}/h = n$ dark phase becoming in certain sense part of subject person. Magnetic flux tubes connecting subject person to a sample of water (or of rice and water) and carrying dark matter would serve as correlates of attention.

   What might be called loving attention would provide metabolic energy to the target and might be essential element in generating the dark phase giving rise to the beautiful crystal patterns. $h_{eff}/h = n$ can be seen as kind of universal IQ: the more the system contains subsystems with large n, the higher its ability to generate conscious information, negentropy, is.

   Therefore choosing randomly a subject person who just says a word with positive or negative meaning but without emotion might not be enough to reproduce Emotos findings. It is also quite possible that the outcome of the experiment is a realization of subject person's intention/desire to have the desired effect. This would not however reduce the profound implications of the findings of Emoto if they are true.

3. Thanks to the presence of dark portion of water, super-cooled water is quantum critical system in TGD Universe. In supercooling the temperature can become considerably lower than in the usual freezing and means that also the dark portion of water stays dark. This dark portion would react to the intentions of subject person. The crystal structures would serve as kind of photograph is of the representations of mental images of the system subject person + dark portion of water.

   Remark: Water normally freezes at 273.15 K (0 °C), but it can be supercooled at standard pressure down to its crystal homogeneous nucleation at almost 224.8 K.

What about the effects of music and even visual pictures on water? Also these effects are in principle possible and would rely on universal representation of emotions in living matter

at molecular and maybe even at higher levels. Since music represents and creates emotions, the natural assumption is that the collection of allowed 3-chords express emotions both at the molecular level and at the level of MB.

1. The resonant interaction by 3-chords made of photons is possible between any pair formed by taking given member to be either DNA, RNA, tRNA or its dark variant. Dark counterparts of AAs would couple resonantly to the frequencies defined as sums of the frequencies of 3-chords. These dark variants of bio-molecules are present also in water if TGD based explanation of Pollack effect is correct. One actually ends up to a model for prebiotic evolution involving dark nuclei made from dark proton sequences in an essential manner [L42, L49](see `http://tinyurl.com/yalny39x` and `http://tinyurl.com/yd5t82gq`).

2. The frequencies of visible light are rather high for the ordinary value of Planck constant. The original motivation for the hierarchy of Planck constants was the finding that ELF em fields have quantal effects on living matter [**?**]. This led to a proposal in which bio-photons at visible and UV frequencies are dark photons at ELF frequencies transformed to ordinary photons [K13]. Also the reverse transformation taking ordinary photons to dark photons is possible so that dark matter - dark variants of AAs responding resonantly to single frequency - at the flux tubes can "see".

3. The effect of words expressing positive emotions would initiate metabolism based on fermentation. The spoken words must serve as encouraging of dis-encouraging control signal just as music of light. The meaning of the words should be same for the subject person and the system rice + water. This can be the case if the systems entangle to single system via flux tube bridges.

   This relates interestingly to the theory of Russian biologist Peter Gariaev based on the assumption that genes define a language in rather concrete sense [I69, I50, I45]. I have developed these ideas from TGD point of view in [L49] (see `http://tinyurl.com/yd5t82gq`): dark variants of genes identified as dark proton sequences - essentially dark variants of nuclei - define a universal language.

4. In the model the 3-chords in question are made of light. In the case of music as we understand it they would be made of sound. In living matter sounds can be transformed to em oscillations by piezo-electric effect. The resulting em oscillations would be accompanied by both ordinary and dark photons, and both the 3-chords and melody of the music would couple to dark dark proton triplets at flux tubes serving as counterparts of DNA, RNA, tRNA, and AAs. If the same mechanism is involved with Emoto's experiments, the sounds should transform to light or they should induce at flux tubes vibrations - dark phonons - at the same frequencies that realize the representation of biomolecules and their dark variants as 3-chords.

   Remark: In TGD Universe physical state as a collection of particles is replaced with a network of flux tubes having particles at its nodes [L26] (see `http://tinyurl.com/y9kwnqfa`). Therefore sound as vibrations of the length of flux tube accompanied by fermionic string connecting pair of nodes becomes fundamental excitation rather than something emerging only at condensed matter physics.

Ugly crystals are assigned with negative emotions and emotions are assigned with harmonies. Harmonies - also those, which are sad (consider only passions of Bach) - are however usually thought of as something beautiful. Can negative emotions really correspond to any bio-harmonies characterized by symmetries. In a discussion with Sini Kunnas I realized that also the notion of disharmony could make sense. There are indeed 6 Hamiltonian cycles without any symmetries [A3, A4, A2]. I neglected them in the model of harmony because they would represent which one might call disharmony. Could one of the contributing 3 Hamiltonian cycles in bio-harmony correspond to this kind of dis-harmony and bring in 20 3-chords without any symmetries? If so the relationship between geometry and aesthetics would become very concrete. The alternative view would be that there are several harmonies realized simultaneously and thi creates disharmony.

3.5 Updated view about the rice experiments of Masaru Emoto

Masaru Emoto has carried out extremely interesting experiments with water at the critical point against freezing. Emoto reports that words expressing emotions are transmitted to water: positive emotions tend to generate beautiful crystal structures and negative emotions ugly ones. Also music and even pictures are claimed to have similar effects. Emoto has also carried out similar experiments with rice in water. Rice subjected to words began to ferment and water subject to words expressing negative emotions began to rot.

3.5.1 Emoto's findings

The Wikipedia article about Masaru Emoto (see `http://tinyurl.com/pqy57jj`) provides a good summary of the experiments of Emoto and provides a lot of links so that I will give here only a brief sketch. Emoto believed that water was a "blueprint for our reality" and that emotional "energies" and "vibrations" could change the physical structure of water. The water crystallization experiments of Emoto consisted of exposing water in glasses to different words, pictures or music, and then freezing and examining the aesthetic properties of the resulting crystals with microscopic photography. Emoto made the claim that water exposed to positive speech and thoughts would result in visually "pleasing" crystals being formed when that water was frozen, and that negative intention would yield "ugly" crystal formations.

In 2008, Emoto and collaborators published an article titled "Double-Blind Test of the Effects of Distant Intention on Water Crystal Formation" about his about experiments with water in the Journal of Scientific Exploration, a peer reviewed scientific journal of the Society for Scientific Explorations (see `http://tinyurl.com/ycsnu2oc`). The work was performed by Masaru Emoto and Takashige Kizu of Emoto's own IHM General Institute, along with Dean Radin and Nancy Lund of the Institute of Noetic Sciences, which is on Stephen Barrett's Quackwatch (see `http://tinyurl.com/y99kol2e`) blacklist of questionable organizations. PSs are the modern jesuits and for jesuits the end justifies the means.

Emoto has also carried experiments with rice samples in water. There are 3 samples. First sample "hears" words with positive emotional meaning, second sample words with negative emotional meaning, and the third sample serving as a control sample. Emoto reports (see `https://youtu.be/Wc-ZmvxfBxE`) that the rice subjected to words with positive emotional content began to ferment whereas water subject to words expressing negative emotions began to rot. The control sample also began to rot but not so fast.

But has anyone replicated the experiments of Emoto?

Has anyone replicated the experiments of Masaru Emoto? This was the question posed to me by Alain Jutras on FB. In the research community very few people want to get a label of crackpot by trying to do something like this. The experiments are however simple and ordinary laymen can do the replication (for a successful replication see this).

When we are talking about Emoto's experiment we make head on collision with physicalism, which identifies as the core of scientific thinking the belief that consciousness has no causal effects so that our desires and intentions cannot have any effects on anything. Giving up this belief would of course pose strong challenges for experimentation: how can we know the desires of the experimenter have not affected the outcome of the experiment? For the skeptic, also free will is an illusion (this implies that also moral and ethics are illusory but usually even the most hardfore skeptics avoids saying this aloud). Some extremists believe that even consciousness is an illusion.

Just for fun I looked at some URLs on the web and found that the typical reaction was that it does not matter whether Emoto's experiments can be replicated or not. Emoto must be a crackpot of fraud. This is idiotism in the veil of scientific thinking and I have learned during years that it is useless to argue with an idiot.

There are of course numerous phenomena suggesting remote mental interactions, where skeptics are forced to give up logical thinking.

1. For instance, in medical experiments, a placebo can produce the same effect as real medicine. For skeptics this shows that the idea about the mind-matter interaction is deadly wrong. Skeptic does not (want to) realize the very placebo effect proves that mind can affect matter!

2. The so-called experimenter effect is well-known and well-documented and is an example of the effect of the desires of experiment on the results (very probably) involving no fraud. In the development of a new medicine the test results can be phantastic but when the tests are repeated years later there is no effect. The reason could be that the interest of experimenters has already faded, and their desire to get nice results has vanished. The nice results were the outcome of desire, which is just the remote mental interaction!

3. Some experimenters get fantastic results from tests of some paranormal effect but it turns out that the results cannot be replicated. The very fact that this could well be the case without fraud shows the existence of remote mental interactions but skeptics manage to not notice this in their arguments. And of course, there is always the easy explanation: an experimenter is a swindler or crackpot or something like that. The researchers of paranormal phenomena are martyrs of modern science!

4. Water memory and homeopathy is a further example: Nobel level scientists have demonstrated it but have been labelled either swindlers or fools. The attitudes to "cold fusion" is a further example of anti-intellectualism in the veil of scientism.

5. The final example is skeptic himself: at least outside the academic environment he believes that he has command of his actions over his body. Why should he have this belief if it is a mere illusion? This question skeptic manages to unask.

The Emoto experiments are especially vulnerable against the attacks of skeptics. First of all, the experimenter must be able to take seriously the idea that the system studied can have emotions, he must be able to perceive the emotional state of the system and be even able to affect it.

The attempt to affect water at freezing point or the rice in a water bottle requires remote mental interaction: one might say that at the level of conscious experience one must be able to fuse with the water. This kind of ability, emotional intelligence, probably requires an empathetic personality and also a long period to develop since developing a deep emotional relationship with a rice bottle is not a one-night stand. If a skeptic (usually not a very empathetic person) tries to replicate the experiments, he probably fails since he wants to fail and because for him the rice is dead matter (as also other people and skeptic himself, if he thinks completely logically).

There is no way to prove to skeptics that these effects are real since in his world view these effects are impossible. Therefore I think that there is only one way to proceed. A new view of fundamental physics based on good philosophy respecting internal logical consistency, consistent with existing physics, solving the anomalies of the existing physics, and predicting a lot of new phenomena is the only way to proceed. Even skeptics must eventually bow to the power of logic.

This theory must explain what consciousness and life are and must provide an elegant identification for emotions as a universal panpsychic phenomenon appearing already at DNA level. This theory must explain emotional intelligence as the ability to sense the emotional state of another system and explain how emotions are expressed, transferred and induced. If this kind of theory exists, there are hopes that human kind eventually gains the ability to study consciousness instead of denying it.

TGD view of the findings

In the sequel I will consider the working hypothesis that the effects are real, and develop an explanation based on TGD inspired quantum biology [K101, K75, K74]. I have developed a model for the findings of Emoto already earlier [L48] [L54] but the updated version of the model involves new elements related to the progress of TGD.

I will also ask new questions. How emotions are communicated at the fundamental level and how a conscious entity can perceive the emotional state of another conscious entity and possibly affect it? What does emotional intelligence mean? How could one assign a measure of conscious

emotional information to the emotional state? How certain sounds or gestures with emotional contents or even pictures can induce emotional response at the fundamental DNA level?

The basic ingredients of the model are following: magnetic body (MB) carrying dark matter as $h_{eff}/h = n$ phases of ordinary matter; communications between MB and biological body (BB) using dark photons able to transform to ordinary photons identifiable as bio-photons; the special properties of water explained in TGD framework by assuming dark component of water implying that criticality for freezing involves also quantum criticality; the special properties of water at the quantum criticality for Pollack effect at physiological temperature, and the realization of genetic code and counterparts of the basic bio-molecules as dark proton sequences and as 3-chords consisting of light or sound providing a universal language allowing universal manner to express emotions in terms of bio-harmony realized as music of light or sound.

The entanglement of water sample and the subject person (with MBs included) realized as flux tube connections would give rise to a larger conscious entity expressing emotions via language realized in terms of basic biomolecules in a universal manner by utilizing genetic code realized in terms of both dark proton sequences and music of light of light and sound.

3.5.2 Bioharmony and the genetic code

The notions of genetic code and bioharmony have evolved gradually during years. The following gives a brief summary of the basic ideas.

Basic ideas of bioharmony

1. The notion of bioharmony is based on the observation that 12-note-scale could correspond to a Hamilton cycle at an icosahedron containing 12 vertices [L15, L56, L70, L77, L98]. The scale would correspond to a Hamilton cycle going through all the vertices just once. Quint cycle is a very attractive identification for the representation of the scale in the sense that neighboring points of the icosahedron correspond to scaling of frequency by factor 3/2 and so that octave equivalence characterizing musical perception gives 12-not scale spanning a single octave.

2. For a given Hamilton cycle, the 20 faces of the icosahedron define 3-chords proposed to correspond to an icosahedral harmony. One obtains a large number of different Hamilton cycles characterized by a symmetry group which is either Z_6, Z_3 or Z_2, which can be generated by reflection or a rotation by π. There are also 6 Hamilton cycles with trivial symmetries (Z_1). Hamilton cycles without any symmetries have an interpretation as disharmonies.

3. The surprising finding was that the 3 icosa tetrahedral 20-chord harmonies: the unique Z_6 harmony, Z_4 harmonies and considerable larger number of Z_2 harmonies give rise to a partial representation of the genetic code in the sense that the orbits of these symmetry groups correspond to amino acids. The number of triangles at a given orbit Z_n is the same as the number of DNAs coding the corresponding amino acid.

   4 codons from 64 codons are however missing. These are obtained by adding a tetrahedral Hamilton cycle with 4 chords and 4 vertices. The conclusion is that genetic code and music harmony might be deeply related.

4. Icosa tetrahedral hyperbolic tessellation [L98] emerges as a unique hyperbolic tessellation involving 3 Platonic solids tetrahedron, octahedron and icosahedron. The proposal is that it could provide a universal representation of the genetic code and associated bioharmony, which is not restricted to biology but applies to all kinds of systems in all scales. One could say that the tessellation is induced (projected) to the 3-surface at hyperbolic space H^3 (light-cone proper time constant surface in M^4 and defines a genetic code for almost any system.

   The 3 Hamilton cycles as representations of 12-note scale give 20+20+20 =60 chords and the tetrahedral Hamilton cycle gives 4 chords. These 64 chords would correspond to genetic codons represented as faces of icosahedron and tetrahedron.

The quantum realization of bioharmony

How to realize bio-harmonies physically if the TGD view of dark matter residing at monopole flux tubes and controlling biomatter is assumed?

1. Dark genome at the magnetic monopole flux tubes paired with DNA and realized in terms of dark protons. Dark 3-proton triplets would represent the 3-chords of the icosa tetrahedral bioharmony. Chords would be assignable to cells of a unique hyperbolic icosa tetrahedral tessellation containing icosahedron, octahedron and tetrahedron as basic units. These three Platonic solids have triangular faces so that they can be glued together.

   The icosa tetrahedral tessellation of H^3 would induce a tessellation of the 3-surface $X^3 = X^4 \cap H^3 \times CP_2$, where $X^4 \subset H^3 \times CP_2$ denotes the space-time surface [L98]. The octahedrons belonging to the tessellation would have naturally a passive role since all faces could be regarded as either icosahedral or tetrahedral. Codons would be realized in terms of dark proton triplets assigned to vertices of the triangular faces of the tessellation.

2. Dark photon triplets as cyclotron frequency triplets, 3-chords, induce transitions between the states of dark proton sequences. Differences of cyclotron frequency triplets would correspond to dark photon triplets which can induce transitions between dark proton triplets. This realization came rather recently and it is still somewhat unclear whether the chords correspond to the differences of the triplets or to triplets. Also pairs of frequencies and even a single frequency can induce transitions in which 2 or only one frequency of the chord changes.

3. TGD leads also to a speculative generalization of genes. Not only dark codons would be possible but also sequences of dark codons forming dark 3N-protons behave as quantum units, dark genes. They can emit and absorb dark 3N-photons inducing transitions between dark genes as 3N resonances.

   For a given bioharmony, the dark codons and dark genes would effectively serve as addresses and given dark 3N-photon could induce transitions only between dark genes for which its 3N cyclotron frequencies would correspond to differences of the cyclotron frequencies.

   Also partial resonance is enough and even a single dark photon can induce transition between two dark genes. Several transitions are possible if only a single dark proton makes a cyclotron transition. It is also possible that the transformed dark gene belongs to a different bioharmony.

   This leads to a view of how dark genes control ordinary genes.

1. Dark biomatter as $h_{eff} = nh_0$ phases at magnetic monopole flux tubes of the magnetic body (MB) of the system should act as a boss receiving information from the ordinary biomatter controlling it. This strongly suggests that the dark and ordinary information molecules, in particular genes are paired and form helical structures. A rather detailed view of this idea was developed in [L98].

2. The control and communication between dark and ordinary genes would involve the transformation of dark photons to ordinary photons, possibly identifiable as bio-photons, or vice versa. This applies also to the communications of dark and ordinary counterparts of the other information molecules and would be essential in the processes like transcription and translation. Dark 3N-photons as quantum coherent units could decay to 3N ordinary photons. The communication would involve energy resonance but not frequency resonance since h_{eff} changes. A full 3N-resonance is not needed.

3. The resonance condition requires that the dark cyclotron energies and corresponding transition energies assignable to ordinary DNA are identical. The frequency increases since h_{eff} decreases. The transitions of ordinary information molecules need not be cyclotron transitions but can correspond to ordinary chemical transitions. This gives a strong constraint to the values of h_{eff}. This poses strong constraints on both the ordinary and dark information molecules and could have led to a selection of the DNA, RNA and tRNA codons and amino-acids.

4. The original long held belief was dark genes as sequences if 6 bits are identical with the ordinary genes. There is actually no need to assume this. Both the bioharmony and bits can be dynamical. Even the bioharmionies of the dark codons can be dynamical and the dark bioharmony should be consistent with the transition energy spectrum of the ordinary genetic codons only during their mutual communications. 3N-photons of dark genes or thei substructures should induce transitions of ordinary genes in order to make control possible. Dark genes pairing with DNA would make the DNA a cognitive unit consisting of units of 6 bits, an intelligent entity. It would also have emotions and perhaps also emotional intelligence due to the existence of several bio-harmonies.

1. About the symmetries of dark codons

Before continuing one must consider the symmetries of the bioharmony.

1. An open question is whether the dark 3-chords related by a permutations of vertices should be identified or not. If they are regarded as different, there are (3!=6 non-equivalent chords). If a full permutation invariance is allowed, it does not make sense to speak of permutations of the vertices of F and the transitions inducing changes of the 3-chord would not be possible since they could correspond to vanishing energy change of cyclotron energy.

2. In the case of ordinary DNA the order of nucleotides matters and one has 3! different orderings. Now however the codons are quantum entangled units of 3 dark protons so that the situation is not so simple. If the cyclotron frequency spectra assignable to the vertices are not identical then one can say that dark protons are ordered. In this case either of these options is relevant.

3. An interesting possibility is that the 3-chords related by cyclic permutations are equivalent. There would be only 2 non-equivalent 3-chords with different total cyclotron energies and they would have opposite orientations which might be interpreted in terms of parity violation. This would double the number of physically realizable chords and the problem associated with the physical realization of the codons is that the number of codons is by a factor 1/2 too small for the simplest proposals.

4. If a full permutation invariance is allowed it does not make sense to speak of permutations of the vertices of F and the transitions inducing changes of the the 3-chord would not be possible since they could correspond to vanishing energy change of cyclotron energy. If only cyclic invariance is assumed, one can reach 2 vertices/notes from a fixed vertex/note of F by a reflection which permutes the vertices and changes the total cyclotron energy.

2. Does the notion of bioharmony relate to the ordinary notion of harmony

It would be nice to have a contact with the ordinary notion of harmony in which the numbers of chords are small and the 12-note scale is replaced by the 8-note scale or 5-note scale and one has minor and major scales or fusion of them to a scale containing 9 notes.

At the fundamental level music should induce transitions between the codons of a bioharmony so that it is natural to study the transitions changing the dark codons. Consider now the possible transitions changing the 3-chord represented as 3-proton state and induced by one or more dark photons.

1. For a given icosahedral triangular face F and given bioharmony, one can consider the neighboring faces of F, which have either 3, 2, 1 common vertices reachable by a transition induced by be keeping the face/3-chord fixed, keeping one edge (2 notes) fixed, or keeping 1 vertex/note fixed. If there are no common vertices, the initial and final chords have no common frequencies. Also these transitions are possible.

2. For transitions leaving a single edge E/note pair fixed, there are 3 faces/3-chords reached by reflection with respect to E. One could call them inner faces/chords. There are 6 faces/chords reached by keeping a single vertex/note fixed: these faces/chords could be called outer chords.

The total number of faces/chords reached by edge and face preserving transitions is 6+3=9=10-1, where 10 is half of the number of faces of the icosahedron. If the orientation of the fae matters, 10 faces are reached. The faces belonging to the complement of these 10 faces require the change of all frequencies.

The inner 3+1=4 faces define 4 3-chords and 6 outer faces define 6 3-chords: 10 chords altogether making 1/2 of all 3-chords. Could they be regarded as simpler sub-harmonies of the 64 chord harmony?

3. The Hamiltonian cycle has 12 vertices and 3 of them must belong to the complement of the reachable region and should define a triangle by the reflection symmetry of the icosahedron. One would have dual sub-harmonies. Could they somehow relate to the minor and major scales? Or could they relate to DNA strand and conjugate strand? The outer faces contain 6 vertices, which do not belong to F so that the reachable region contains 6+3=9 vertices. Could this have something to do with the 8-note scale which has actually only 7 notes by octave equivalence. The minor scale has two additional notes since the scale ($AHCDEF\sharp F\sharp A$ differs from its reversal $AGFEDCHA$: this would make 9 notes/vertices. For a given base note the number of notes of minor and major scale is 9.

4. From a given vertex of F, one can reach 3+1 outer vertices and 2 vertices of F if reflection symmetry is not true. Could the pairs formed by the fixed vertex of F and these vertices define 6 notes which define allowed changes of notes for a melody. Interestingly, the 8-note scale (C,D,E,F,G,A,H) allows 6 non-trivial intervals ({(C,D), (C,E), (C,F), (C,G), (C,A),(C,H)}).

3.5.3 The interpretation of bioharmonies in the framework of the TGD inspired theory of consciousness

The key idea is that music expresses and generates emotions. Harmony dictates the emotional tone of music and this suggests that bioharmonies are correlates for emotions and that emotions are realized already at the molecular level.

Empirical support for the notion of bioharmonies as correlates for emotions

There is empirical support for the idea that bio-harmonies correlate with emotions.

1. RNA seems to represent and transfer emotions [**?**] (see `http://tinyurl.com/y92w39gs`) [L48]. RNA from the brain of a snail conditioned by a painful stimulus is transferred to the preparation made from neurons of sea slug. Neuron preparation in the Petri dish reacts to the conditioning stimuli as if it were itself conditioned.

2. Somehow RNA is able to transfer emotions. The TGD inspired proposal [L15, L95, L42, L70, L44] [L48] is that dark DNA and RNA represent emotions as sequences of 3-chords made of dark photons of dark RNA form 3N-dark photons behaving like a single quantum coherent unit. The representation of the genetic code would rely on icosa-tetrahedral representation in which the 3-chords would correspond to triangular faces of icosahedron and tetrahedron to which 3-chords are assigned.

3. The first proposal was that the induction of emotions could take place by 3N-resonant cyclotron absorption of dark 3N-photons by dark genes represented as sequences of 3N dark proton triplets at monopole flux tubes of MB. Also the absorption of dark photon singlet or doublet by a dark codon is enough to induce transition between dark codons and therefore between dark genes. This would "wake-up" the dark gene and induce emotional response.

Emotions are expressed and emotional expression induces emotions

Assume that emotions reduce to the DNA level or at least, that they are realized at DNA and biomolecular level. One can pose several questions. What are emotions? How are they expressed? How does emotional expression induce emotions? How are emotions perceived?

1. The universality and uniqueness of the hyperbolic tetra icosahedral tessellation suggests that the notions of bioharmony and moods are universal and can be defined at the level of DNA and other bio-molecules and could even generalize to even larger structures by inducing the icosa-tetrahedral structure to the 3-surface associated with the structure.

2. Moods at the bio-molecular level would correspond to bio-harmonies realized in terms of dark genes represented as sequences of dark codons representable as dark proton triplets. The dark genes would be dynamical unlike the ordinary genes and dark bioharmony would only correspond to the transition energies of DNA only during control and communications. Dark genes would therefore represent intelligence in both cognitive (bit) sense and emotional sense.

3. The basic idea is that music induces emotions and expresses them.How this would be realized at the level of bioharmonies. The first guess is that the emotional state is represented by 3N-chords defining a bioharmony and identified as dark proton triplets, dark genetic codons. The original proposal was that dark photon triplets define another representation of the dark code. This would not be the case: dark photon frequency triplets could correspond to differences of the frequency triplets assignable to dark proton triplets. With this interpretation the notes and chords of music would correspond to the differences of chords and notes for the bio-harmonies.

   This interpretation also allows us to consider temporal patterns of dark codons defining a sequence of 3-chords as a kind of music piece. The dark 3N-photon triplets and also dark photon singlets and doublets induce cyclotron transitions between these triplets if the bio-harmonies of the sender and receiver are the same. Otherwise only some chords induce transitions or only some notes of a given chord. One can even consider transition of entire dark genes by using dark 3N-photons.

4. Systems A and B with the same bioharmony, have the same emotional state, can be in emotional resonance. Transitions between different chords induced by dark photon triplets generated by codon A induce transitions of codon B producing temporal sequences of 3-chords, music pieces!

5. The resonance can be also partial so that all notes of the dark codon are not affected. For instance sequence of notes can induce transitions between chords if the two chords belong to the same 20-codon bioharmony. This is the case always for the codons with Z_6 symmetry.

   A melody, which is consistent with a given bioharmony, involves only notes belonging to the chords of the harmony so that it can induce a transition at a level of single chords. The number of these notes should be maximal. An emotionally intelligent conscious entity should have a wide repertoire of bio-harmonies and be able to rapidly find a bioharmony to generate emotional resonance to the signals of another conscious entity.

6. Cyclotron transitions would form a representation of bioharmony analogous to music piece. Reading of a gene could give rise to a music piece as a sequence of 3N-chords. The interpretation as a melody consistent with given bioharmony should make sense.

How to perceive the bioharmony, resonate with it, and modify it?

In the sequel I christen the sender of emotional signal Alice and its receiver Bob since the world of physics contains only spherical cows besides Alice and Bob. Human interaction involves emotional aspects. In the ideal case, Alice and Bob are able to sense each other's emotional states and are able to communicate their emotions. Empathetic Alice with noble goals can even change the mood of Bob from confused or sad to vsl and happy. Empathy does not mean benevolence. Hitler was known as a very empathetic person. Empathetic but malevolent Alice can do the opposite. What could be the description of this at the fundamental level?

1. Even a single note of a melody can induce a transition between chords of a given bioharmony represented as dark codons if it corresponds to a difference of notes of two chords. Note or several of them can change the chord so that it does not belong to the same bioharmony anymore. This would tend to change the mood.

If Alice is an empathetic listener not trying to affect the mood of Bob, she must use frequencies, which resonantly induce transitions between the chords of the bioharmony of Bob. Alice and Bob must be tuned: i.e. they must have the same bioharmony with the same frequency scale.

2. The ability to resonate with Bob requires that the signal sent by Alice contains peak frequencies, which belong to the bioharmony of Bob. To be empathetic, Alice should be able to sense the frequencies associated with the chords of Bob's bioharmony. From these frequencies Alice might be even able to deduce the chords of the bioharmony of Bob.

   If Alice manages to do this, she has the gift of empathy or emotional intelligence. Autists might be regarded as people with a low level of emotional intelligence and the reason might be that they are not able to perceive the needed frequencies. Perhaps mirror neurons play an essential role here in detecting these frequencies.

   Empathy has nothing to do with the moral or ethical standards of Alice. Alice can do several things. She can generate resonant transitions supporting the bioharmony of Bob. She can also try to modify the mood of sad Bob, say comfort him. Alice can do this by generating frequencies which affect the chords of the bioharmony of Bob so that it changes.

   If Alice is malevolent, she can modify the bioharmony of Bob so that his mood becomes sad or depressed. If Alice is a psychopath, she can even force a disharmony without any symmetries leading to a total emotional confusion. Basically Alice makes a choice between good and evil. Perhaps the ugly words do just this at the level of the DNA of rice in Emoto's experiments whereas nice encouraging words do the opposite.

How the voices or gestures of Alice are transformed to dark photons, their triplets or even dark genes?

1. The voice of Alice could be transformed to dark photons with the same frequency spectrum by a generalization of the piezoelectric effect (see this). These dark photons should affect the dark proton sequences of the MB of Bob at the biomolecular level in order to generate an emotional response.

2. The frequencies must be consistent with the bioharmony of Bob and define the emotional color of the speech of Alice, which can be warm or cold or lacking emotional content altogether if Alice and B are not emotionally "tuned". Also the gestures of Alice should be coded to the sequences of dark photons or even of dark photon triplets representing kind of emotional music pieces. The notes of the melody should correspond to differences for the chords of the bioharmony in question.

Negentropy of bioharmony

Dark genetic code consists of 6-bit units and this aspect corresponds to the ordinary DNA as a bit sequence. Besides this there is bioharmony which relates to the information represented as emotions instead of bits. Emotional intelligence measures the ability to perceive the emotional state. One cannot give a simple measure for this ability. One can however consider information measures for the bioharmonies.

1. One can assign to the bioharmony a measure of its algebraic complexity and information content. The value of $h_{eff} = nh_0$, where n is a dimension of algebraic extension involved, would define a kind of IQ and perhaps also EQ. One can also assign a negentropy to the bioharmony, which could measure its information content. Of course, the EQ characterizes the ability to perceive the emotional state, and is not a property of bioharmony.

2. The intuitive picture is that the negentropy of the bioharmony characterizes the symmetries of the bioharmony. For a given bioharmony, one has 3 icosahedral symmetry groups Z_6, Z_4, and Z_2 corresponding to the 3 20-codon bio-harmonies. The symmetry group of a given 20-codon icosahedral code has orbits such that each codon at a given orbit codes for the same amino acid. There can be several orbits coding for the same amino acid. The k:th orbit contains n_k codons.

3. Consider first the definition of the entropy. The expression for the entropy of given bioharmony could be defined by the probabilities that a given chord belongs to the k:th orbit with n_k chords. The 3 20-chord harmonies are independent and the icosahedral contribution to the entropy is the sum $\sum_{K=1}^{3} S_K$ of the entropies S_K associated with them. Also the tetrahedral contribution is present. One would have $S = -\sum p_k log(p_k)$. p_k would be given by $p_k = n_k/N$, where $N = 20$ is the total number of chords in the icosahedral case $N = 4$ is the total number of chords in the tetrahedral case.

4. One wants to assign an information measure, negentropy to cognition. p-Adic number fields serve as correlates of cognition. Formally the definition is similar to that for entropy: one sums over the contributions of 3 icosahedral harmonies and the unique tetrahedral harmony. For a given p-adic prime p, one can define p-adic negentropy $N_p = \sum p_k log(N_p(p_k))$, where $N_p(p_k)$ is the p-adic norm of the probability. Rather remarkably, this negentropy can be positive unlike entropy.

   One can also define the sum $\sum_p N_p$ of the p-adic negentropies as the total p-adic negentropy. This sum involves only a finite number of terms since the probabilities are rational numbers and the p-adic norm differs from unity only if p divides the numerator or denominator of p. In this way one obtains non-negative information measure. It can be shown that the difference N-S is non-negative.

3.5.4 How to understand Emoto's experiments with freezing water and rice?

In Emoto's experiments with water at freezing point and with rice the emotional tone of the spoken words has a surprising effect on the system. How to understand this? Water is fundamental for life and in the TGD based view of life quantum criticality is fundamental for life and conscious intelligence.

Water makes possible quantum critical fluctuations involving large values of h_{eff} measuring the algebraic complexity of the quantum state and also serving as a kind of IQ. The criticality for freezing and also other phase transitions would be basically quantum criticality and could have been essential for the emergence of primordial life. The ice crystals found by Emoto in the experiments could be corpses of small primordial life forms formed by water molecule clusters. They would be especially favored at quantum criticality and would have dark genetic code which would make it possible for these life forms to experience emotions. The biochemical realization of the genetic code would have emerged much later but would not be essential for the conscious emotional experience.

In the rice experiments, the Pollack effect [I48, L16, **?**, I66] could play a key role [L91, L87]. The physiological temperature would be the quantum critical temperature for the phase transition taking place in the Pollack effect. Pollack effect creates matter with a very large value of $\hbar_{eff} = \hbar_{gr}$, where $\hbar_{gr}$ is gravitational Planck constant introduced by Nottale [E2] characterizing the monopole flux tubes of the gravitational fields of the Sun, Earth and also other planets. In the Pollack effect, incoming photons kick protons to dark protons at the gravitational magnetic flux tubes. This gives rise to negatively charged exclusion zones characterizing cells and DNA.

Pollack effect would be associated with the sol-gel phase transition. Pollack effect is also essential for the metabolism and photosynthesis. Pollack effect requires energy feed and for instance solar radiation can provide it. Also the formation of molecules from atoms can liberate the needed energy.

The dark protons would be associated with the magnetic bodies of water molecule clusters. Water memory and homeopathy would involve Pollack effect and would be associated with primordial life forms formed by water clusters [K49]. Water memory would allow the magnetic bodies to recognize and mimic the magnetic bodies of the invader molecules as small life forms with the same cyclotron energy spectrum. This would make possible the evolution of the immune system and of chemical life.

Also the electric counterpart of the gravitational quantum coherence is possible in the long range classical electric fields of Sun, Earth and also of smaller objects is an essential element of life [L100]. The long range electric fields associated with the central nervous system might involve macroscopic quantum coherence with a large value of h_{em}.

An induction of emotions similar to that occurring in human interactions could take place in the experiments of Emoto and transform the words of the experimenter to dark photon signals affecting the DNA and RNA of the rice. It is the peak frequencies determining the emotional tone which matter, not the content of the words in the usual sense. If the emotions are indeed universal at the level of dark genes, the emotional aspects of voice would be emotional also from the point of view of rice in water.

The words with an unfriendly tone would change the bioharmony to a less negentropic one. Friendly words would cause the opposite. This would not be about a direct modification of the metabolic energy feed but about its utilization: depressed people lose their appetite and this leads to metabolic deprivation. The sum of p-adic negenetropies provides a quantitative measure for the negentropy of the bioharmony and it also could also serve as a parameter characterizing the mood.

3.6 Emotions and RNA

In the following fascinating findings related to RNA and possibly expression of emotions at molecular level are discussed.

3.6.1 Does RNA code for pain?

I learned about an extremely interesting finding [**?**] (see `http://tinyurl.com/ycqxyeqk`) in neuroscience. The popular article " *Scientists Sucked a Memory Out of a Snail and Stuck It in Another Snail*" (see `http://tinyurl.com/y92w39gs`) tells that the conditionings of snails produced by painful sensations can be transferred to other snails or even snail neurons in Petri dish by adding just the RNA of the conditioned snails to the dish!

Let us summarize the findings.

1. RNA from snails is transferred to snails or to even populations of snail neurons in Petri dish!

2. The effect involves epigenetic changes in DNA by methylation induced by RNA somehow. The reaction is to the serotonin informing for the stimulus. Avoidance behavior emerges as a response.

3. How does RNA induce the epigenetic change? RNA should couple to a a specific part of DNA and induce the effect. A pairing of DNA with RNA in question occurring also in transcription suggests itself strongly.

4. What in the RNA of the conditioned snail is different? RNA should somehow code for the conditioning induced by a painful sensory experience. RNA of sensory receptors should change somehow and communicate this change to DNA in brain by some mechanism. DNA-RNA pairing does not seem plausible. Could the pairing occur by some other means?

Before continuing it is good to summarize the TGD based models for music harmony providing also a model of genetic code (see `http://tinyurl.com/yad4tqwl`), for sensory perception (see `http://tinyurl.com/yczv2o5b`), for emotions (see `http://tinyurl.com/ydhxen4g`), and for impriting of emotions in water (see `http://tinyurl.com/ycdywctw`).

1. TGD based model for emotions and communication of emotions suggests that the communication takes place in terms of what I call music of light (also sound might be involved). Music expresses and creates emotions. Emotional state, mood, is coded by harmony or disharmony for music of light.

   12-note is fundamental for music and is represented as a closed self-non-intersecting path (Hamilton cycle) at icosahedron having 12 vertices. Icosahedron has 20 faces (triangles) and for given Hamilton cycle one can assign a 3-chord to each triangle. This gives 20-chord harmony (or disharmony). There is quite large number of 20-chord harmonies and those allowing Z_6, Z_4 and Z_2 as symmetries is quite large. Besides this there 6 cycles with no symmetries and these could be identified as dis-harmonies.

2. 20 is also the number of amino-acids so that it is not totally surprising that the model for bioharmony as a union of 3 different 20-chord harmonies plus 4-chord harmony assignable to tetrarhedron turns out to give a model of genetic code as 64 chord bioharmony. There are 64 basic 3-chords in one-one correspondence with DNA and RNA codons. tRNA corresponds to a union of 2 20-chord harmonies. Given amino-acid corresponds to the orbit of 3-chord under symmetries of the harmony so that number of 3-chords at the orbit is the number of DNAs coding for the amino-acid. These numbers come out correctly.

3. There are two other representations of genetic code. The ordinary chemical representation and the representation in terms of dark proton sequences at magnetic flux tubes. The model for dark proton triplet predicts that its states divided to 64 analogs of DNA codons, 64 analogs of RNA codons, 40 analogs of tRNA codons, and 20 analogs of amino-acids. Genetic code comes out correctly also now by a natural pairing of dark proton triplets. One must couple these 3 representations of genetic code with themselves and with each other.

4. There is indeed resonant coupling by 3-chords realized in terms of free frequencies of dark photons. The frequencies are rather low ($E = h_{eff} \times f$, $h_{eff}/h = n$) but energies are same as for biophotons with energies in visible and UV range.

   Also dark variants of DNA, etc couple with each other via dark photon resonance. Dark DNA, etc couple with ordinary DNA, etc.. by energy resonance to form double strands. This means that dark photon transforms to ordinary photon in the coupling. Amino-acid couples to single frequency, which is the sum of codon frequencies coding for it.

   There is quite large number of 3-chord 3-harmonies defining DNA and RNA moods, and 3-chord 2-harmonies tRNA moods, and amino-acid 1-chord harmonies. There also 6 disharmonies with 20 chords each possible assignable to negative moods such as those generated by pain.

So: Is the communication chemical by DNA-RNA pairing or by some other means? TGD based model suggests "some other means".

1. Pain in sensory receptor is certainly involved. In TGD based model differs from neuroscience view in that for sensory experiences sensory receptors are seats of the sensory qualia and brain only forms cognitive representations about them and also entangles with sensory receptors to share the pain. Somehow pain must affect RNA in sensory receptors? How?

2. In this framework the stimulus in nocireceptors would induce a disharmony expressed in terms of the disharmony associated with the expression of RNA in terms of 3-chords. The dark variant of RNA in pain receptors would entangle with the dark DNA in certain neurons in brain of the snail. Nerve pulse patterns from the nociceptors would generate also magnetic flux tube connections parallel to the sensory pathway in question and make possible the communication by dark biophoton triplets to brain possible. The dark variant of DNA in brain would have resonant coupling with ordinary DNA and induce the epigenetic change by methylation as a response to the negative mood with the mediary of biophotons. After this the organism would have avoidance behaviour towards the stimulus inducing the pain.

3. The presence of mere RNA and associated dark RNA dis-harmonious mood would do the same for any neuron by the resonance mechanism. This would allow to transfer emotions even to snail neurons in Petri dish, not only those in living snails.

The proposed mechanism provides insights to many other poorly understood problems.

1. This mechanism also allows to understand how the transfer of emotions conditioning induces epigenetic chance also in the germ cell DNA: this is not easy to understand in the standard framework requiring chemical communication through the germ cell membrane.

2. The models for learning (memories restricted to conditionings) based on formation of synaptic contacts on one hand and involving RNA are seen as exclusive in standard neuroscience. In TGD framework the formation of synaptic contacts might rely at the fundamental level on

the same epigenetic mechanism. Neuromodulators might induce the emotional states in RNA in turn doing the epigenetic editing.

In human brain the genomes differ in various neurons and epigenetic editing by the proposed mechanism might cause this. An interesting question is whether humans could edit their genomes intentionally. All conditionings are not useful and maybe it becomes someday possible to affect these conditionings at the level of dark DNA.

3. Squid and octopus are known to be able to edit their mRNA (see `http://tinyurl.com/m7m6c28`). Instead of DNA the mRNA produced in the transcription so that the translation produce different protein. The effect of emotional states of the dark variant of RNA associated with mRNA could be the mechanism involved.

4. The strong emotional state of single individual induces very effectively the same emotional state in people around: consider only concert as an example. Could the "music of dark light" mediate the emotions from the dark RNA of individual - say artist - to people around. If so all art would be basically music of light!

To sum up: this finding provides rather concrete support for the vision that emotions are coded by the music of light at molecular level.

3.6.2 Did RNA replicate in codon-wise manner during RNA era?

There was an interesting popular article in Spacedaily with title "*Scientists crack how primordial life on Earth might have replicated itself*" (see `http://tinyurl.com/y92ng5vd`). The research paper [I28] is titled "*Ribozyme-catalysed RNA synthesis using triplet building blocks*" and published in eLife (see `http://tinyurl.com/ya5qyjfn`).

It is possible to replicate unfolded RNA strands in Lab by using enzymes known as ribozymes, which are RNA counterparts of enzymes, which are amino-adic sequences. In the presence of folding the replication is however impossible. Since ribozymes are in general folded, they cannot thus catalyze their own replication in this manner. The researchers however discovered that the replication using RNA triplets - genetic codons - as basic unit can be carried out in laboratory even for the folded RNA strands and with rather low error rate. Also the ribozyme involved can thus replicate in codon-wise manner. For units longer than 3 nucleotides the replication becomes prone to errors.

These findings are highly interesting in TGD framework. In TGD the chemical realization of genetic code is not fundamental. Rather, dark matter level would provide the fundamental realizations of analogs of DNA, RNA, tRNA, and amino-acids as dark proton sequences giving rise to dark nuclei at magnetic flux tubes [L42] (see `http://tinyurl.com/yalny39x`). Also ordinary nuclei correspond in TGD Universe to sequences of protons and neutrons forming string like entities assignable to magnetic flux tubes.

The basic unit representing DNA, RNA and tRNA codon and amino-acid would consist of 3 entangled dark protons. The essential aspect is that by entanglement the dark codons do not decompose to products of letters. This is like words of some languages, which do not allow decomposition to letters. This representation is holistic. As we learn to read and write, we learn the more analytic western view about words as letter sequences. Could the same hold true in evolution so that RNA triplets would have come first as entities pairing with dark RNA codons from from dark proton triplets as a whole? Later DNA codons would have emerged and paired with dark DNA codons. Now the coupling would have have been letter by letter in DNA replication and transcription to mRNA.

It is intriguing that tRNA consists of RNA triplets combined from amino-acids and analogs of mRNA triplets! The translation of mRNA to amino-acids having no 3-letter decomposition alone forces the holistic view but one can ask whether something deeper is involved. This might be the case. I have been wondering whether during RNA era RNA replicated using a prebiotic form of translational machinery, which replicated mRNA rather than translated RNA to protein formed from amino-acids (AAs) with AA serving as a catalyst.

1. During RNA era amino-acids associated with pre-tRNA molecules would served as catalysts for replication of RNA codons. The linguistic mode would have been "holistic" during RNA

era in accordance with the findings of the above experiments. RNA codon would have been the basic unit.

2. This would have led to a smaller number of RNAs since RNA and RNA like molecules in tRNA are not in 1-1 correspondence. A more realistic option could have been replication of subset of RNA molecules appearing in tRNA in this manner.

3. Then a great evolutionary leap leading from RNA era to DNA era would have occurred. AA catalyzed replication of RNA would have transformed to a translation of RNA to proteins and the roles of RNA and AA in tRNA would have changed. [Perhaps the increase of h_{eff} in some relevant structure as quantum criticality was reached led to the revolution]

4. At this step also (subset of) DNA and its transcription to (a subset of) mRNA corresponding to tRNA had to emerge to produce mRNA in transcription. In the recent biology DNA replicates and is transcribed nucleotide by nucleotide rather than using codon as a unit so that helicases and DNA and RNA polymerases catalyzing replication and transcription should have emerged at this step. The ability of DNA to unwind with the help of helicase enzyme helping DNA to unwind is essential for the transcription and translation of DNA. Therefore helicase must have emerged together with the "analytic linguistic mode" as an analog of written language (DNA) decomposing codons to triplets of letters. This would been a crucial step in evolution comparable to the emergence of written language based on letters. Also the counterpart of RNA polymerase and separate RNA nucleotides for transcription should have emerged if not already present.

   An alternative option would involve "tDNA" as the analog of tRNA and the emergence of helicase and polymerases later as the transition from holistic to analytic mode took place.

   The minimal picture would be emergence of a subset of DNA codons corresponding to RNAs associated with pre-tRNA and the emergence of the analogs of helicase and DNA and RNA polymerases as the roles of amino-acid and RNA codon in tRNA were changed.

5. How DNA could have emerged from RNA? The chemical change would have been essentially the replacement of ribose with de-oxiribose to get DNA from RNA and U$\rightarrow$ T. Single O-H in ribose was replaced with H. O forms hydrogen bonds with water and this had to change the hydrogen bonding characteristics of RNA.

   If the change of $h_{eff} = n \times h_0$ was involved, could it have led to stabilization of DNA? Did cell membrane emerge and allow to achieve this? I have proposed [L42] (see `http://tinyurl.com/yalny39x`) that the emergence of cell membrane meant the emergence of new representation of dark genetic code based on dark nuclei with larger value of h_{eff}.

   Remark: One has $h = 6 \times h_0$ in the most plausible scenario [L27, L47] (see `http://tinyurl.com/goruuzm` and `http://tinyurl.com/y9jxyjns`).

The communication between dark and ordinary variants of biomolecules involves resonance mechanism and would also involve genetic code represented as 3-chords, music of light, and it is interesting to see whether this model provides additional insights.

1. The proposal is that 3-chords assignable to nucleotides as music of light with allowed 64 chords defining what I have called bio-harmony is essential for the resonance [L48, L49, L47](see `http://tinyurl.com/ydhxen4g`, `http://tinyurl.com/yd5t82gq`, and `http://tinyurl.com/y9jxyjns`). The 3 frequencies must be identical in the resonance: this is like turning 3 knobs in radio. This 3-fold resonance would correspond to the analytic mode. The second mode could be holistic in the sense that it would involve only the sum only the sum of the 3 frequencies modulo octave equivalence assigning a melody to a sequence of 3-chords.

2. The proposal is that amino-acids having no triplet decomposition are holistic and couple to the sum of 3 frequencies assignable to tRNA and mRNA in this manner. Also the RNAs in tRNA could couple to mRNA in this manner. One could perhaps say that tRNA, mRNA and amino-acids codons sing whereas DNA provides the accompaniment proceeding as 3-chords. The couplings of DNA nucleotides to RNA nucleotides would rely on the frequencies assignable to nucleotides.

3. If the sum of any 3 frequencies associated with mRNA codons is not the same except when the codons code for the same amino-acids, the representation of 3-chords with the sum of the notes is faithful. The frequencies to DNA and RNA nucleotides cannot be however independent of codons since the codons differing only by a permutation of letters would correspond to the same frequency and therefore code for the same amino-acid. Hence the information about the entire codon would be needed also in transcription and translation and could be provided either by dark DNA strand associated with DNA strand or by the interactions between the nucleotides of the DNA codon.

4. The DNA codon itself would know that it is associated with dark codon and the frequencies assignable to nucleotides could be determined by the dark DNA codon. It would be enough that the frequency of the letter depends on its position in the codon so that there would be 3 frequencies for every letter: 12 frequencies altogether.

   What puts bells ringing is that this the number of notes in 12-note scale for which the model of bio-harmony [L15, L48] (see `http://tinyurl.com/yad4tqwl` and `http://tinyurl.com/ydhxen4g`) based on the fusion of icosahedral (12 vertices and 20 triangular faces) and tetrahedral geometries by gluing icosahedron and tetrahedron along one face, provides a model as Hamiltonian cycle and produces genetic code as a by-product. Different Hamiltonian cycles define different harmonies identified as correlates for molecular moods.

   Does each DNA nucleotide respond to 3 different frequencies coding for its position in the codon and do the 4 nucleotides give rise to the 12 notes of 12-note scale? There are many choices for the triplets but a good guess is that the intervals between the notes of triplet are same and that fourth note added to the triplet would be the first one to realize octave equivalence. This gives uniquely $CEG\sharp$, $C\sharp FA$,$DF\sharp B\flat$, and $DG\sharp B$ as the triplets assignable to the nucleotides. The emergence of 12-note scale in this manner would be a new element in the model of bio-harmony.

   There are 4!=24 options for the correspondence between $\{A,T,C,G\}$ as the first letter and $\{C,C\sharp,D,D\sharp\}$. One can reduce this number by a simple argument.

   (a) Letters and their conjugates form pyrimidine-purine pairs T,A and C,G. The square of conjugation is identity transformation. The replacement of note with note defining at distance of half-octave satisfies this condition (half-octave - tritonus - was a cursed interval in ancient music and the sound of ambulance realizes it). Conjugation could correspond to a transformation of 3-chords defined as

   $$CEG\sharp \leftrightarrow DF\sharp B\flat \quad , \quad C\sharp FA \leftrightarrow D\sharp GB \quad .$$

   (b) One could have

   $$\{T,C\} \leftrightarrow \{CEG\sharp, C\sharp FA\} \quad , \quad \{A,G\} \leftrightarrow \{DF\sharp B\flat, D\sharp GB\} \quad ,$$
   $$\text{or}$$
   $$\{T,C\} \leftrightarrow \{DF\sharp B\flat, D\sharp GB\} \quad , \quad \{A,G\} \leftrightarrow \{CEG\sharp, C\sharp FA\} \quad .$$

   .

   (c) One can permute T and C and A and G in these correspondences. This leaves 8 alternative options. Fixing the order of the image of (T,C) to say $(C,C\sharp)$ fixes the order of the image of (A,G) to $(D,D\sharp)$ by the half-octave conjugation. This leaves 4 choices. Given the bio-harmony and having chosen one of these 4 options one could therefore check what given DNA sequence sounds as a sequence of 3-chords [L15].

That the position the frequency associated with the nucleotide depends on its position in the codon would also reflect the biochemistry of the codon and this kind of dependence would be natural. In particular, different frequencies associated with the first and third codon would reflect the parity breaking defining orientation for DNA.

3.6.3 How do slime molds learn?

Quanta Magazine is a treasure trove of popular articles about hot topics in basic research and biology and neuroscience are the hottest topics now. The popular article "*Slime Molds Remember — but Do They Learn?*" about learning of slime molds (see `http://tinyurl.com/ydc8gh4d`) serves as a good example of pleasant surprises popping up on weekly basis. There are several research articles referred but the related to the following comments are about the work of Dussutour and others [I14, I19] (see `http://tinyurl.com/hbo88c` and `http://tinyurl.com/y83o5sfs`).

1. The popular article tells that slime molds are monocellulars - for long time believed to belong to fungi - but actually somewhat like amoebas. They have neither neurons nor brains. The neuroscientific dogma says that neurons are necessary for learning so that slime molds should not learn. They should only adapt by selecting behaviors from a genetically inherited repertoir. Same would be true about plants, which are also known to learn.

   For physicist these beliefs look strange. Both animals and plants and also slime molds share the basic aspects about what it is to be alive, why should they be unable to learn? The research of biologist Audrey Dussutour and her team described in the article indeed shows that slime molds are indeed able to learn.

2. Conditioning is the basic mechanism of learning, which by definition leads to a creation of a new kind of behavior rather than selecting some behavior from an existing repertoir as happens in adaptation. Typically the conditioning is created by associating unpleasant sensory stimulus such as electric shock to some other stimulus, which can be pleasant, say information about the presence of food. This leads to avoidance behavior and the mere presence of food can induce the avoidance behavior.

3. It was found that slime mold [I14] learns a habit of avoiding the unpleasant stimulus - habituation is said to take place. Habituation involves generation of new behavior and is not mere adaption. For instance, habituation can mean stopping noticing stimulus like smell if it is not dangerous or important for survival. In the experiments the slime molds were conditioned to avoid noxious substances (having bitter "taste") and they remembered the behavior after a year of physiologically disruptive enforced sleep as the technical terms expresses it. This learned behavior was also transferred in cell fusion to individual that had not learned the behavior [I19].

4. Central nervous system has been believed to be responsible for habituation since neurons receive and process the sensory the stimuli, build kind of cognitive representations about them, and generate motor response. Neuroscientist believe that learning means strengthening of synaptic contacts eventually giving rise to a learned motor response to a sensory stimulus by a sequence of associations

   Against this background the ability of slime molds to learn looks mysterious. How do they perceive the stimulus, how do they process it, how do they respond to it? We know actually little about cognition and learning: we know a lof about the neural correlates of cognition but not what cognition is.

Forgetting the question about what cognition is, one can just ask what could lead to the change of behaviour of the slime mold. Some time ago I learned about another fascinating finding related to learning from the article "*Scientists Sucked a Memory Out of a Snail and Stuck It in Another Snail*" (see `http://tinyurl.com/y92w39gs`). What was found that one can take RNA of a snail that has been conditioned by some painful stimulus and transfer it to another snail by scattering RNA on its brain neurons [**?**]! Same can be achieved also by feeding snail with the conditioned snail. RNA must somehow represent memories. If this is true for snail it can be true also for the slime mold.

Usually learning is assigned with cognition regarded as kind of linguistic cognition. One speaks also of emotional intelligence: could learning be based on emotions? The TGD based model for emotions (see `http://tinyurl.com/ydhxen4g`) inspired by the model of music harmony [L15, L52] (see `http://tinyurl.com/yad4tqwl` and `http://tinyurl.com/y8njuctq`) leading to a model of genetic code predicting correctly vertebrate coderelies on this idea and leads to a model for what learning could be also in the case of slime molds.

1. Music expresses and creates emotions coded in its harmony (think of major and minor scales as simple examples). This could be true in much more general sense. Not only music made of sound but also of light - dark photons in TGD framework - could realize these functions of music. DNA would have a representation in terms of a collection of 3-chords made of three dark photons with frequencies in proportions allowed by the harmony.

2. The model of harmony based on icosahedral and tetrahedral geometries predicts a large number of harmonies representing emotional states, moods. The music of light makes possible communication between DNA, RNA, amino-acids (AAs), even tRNAs and their dark variants DDNA, DRNA, DAA, DtRNA. Communications are possible if the three chords can resonate note by not: ideal situation occurs if the harmony defining the mood is same in sender and receiver. Emphatics are those, who experience also the sufferings of the other people. Moods can be transferred from RNA to DNA and here they can induce epigenetic change leading to a change in behavior.

3. The painful conditioning of snail would induce a new mood of RNA of snail (probably rather depressive!) and this would in turn infect the DNA of the snail (strong emotions are infective) and the mood of DNA would induce the epigenetic change leading to the avoidance behavior (see `http://tinyurl.com/yb4nuumr` and `http://tinyurl.com/ydhxen4g`). Emotions would be behind the learning and learning would take place at DNA level as epigenetic changes changing the gene expression. Habitutation would involve epigenetic changes and adaptation involve only activation of appropriate inherited genes.

It must be added that TGD also leads to a vision about the role of neurons in many aspects different from the neuroscientific view although agreeing with the basic facts and explaining quite a number of anomalies [L33] (see `http://tinyurl.com/yczv2o5b`).

1. The notion of magnetic body (MB) containing dark matter as $h_{eff}/h_0 = n$ phases of ordinary matter is central. The networks having as nodes objects consisting of ordinary matter (molecules, organelles, organs, even organisms) connected to a network made of flux tubes containing dark matter would give rise to both cellular and neuronal networks. Magnetic flux tube connecting two nodes would serve as a correlate of attention and communication pathway using supra currents or dark photons. Also classical signals can propagate along it.

2. The primary function of nerve pulse activity at the level of CNS would not be communication between neurons but building of communication pathways from flux tubes along which dark photon signals can propagate with maximal signal velocity. The situation would be same in travel phone connections: the communication pathway would be created first and only then the communications with light velocity would begin. Synaptic transmission would build a bridge between otherwise non-connected flux tubes. This would give rise to long waveguides. Dark photons transforming to ordinary photons would yield bio-photons, which have remained mysterious in standard bio-chemistry since their spectrum is not consistent with the discrete spectrum of lines produced if they were generated in molecular transitions.

3. Sensory experiences would be basically at the level of sensory organs and sensory percepts would involve pattern recognition involving repeated feedback signal from brain an leading a standard perception nearest to the sensory input. The new view about time provided by zero energy ontology allows to circumvent the counter argument inspired by phantom leg phenomenon.

4. Nerve pulse patterns would frequency modulate the generalized Josephson frequencies assignable to the membrane proteins acting as Josephson junctions and generating dark Josephson radiation as part of EEG propagating to the MB of the system. Thus nerve pulse patterns would code information but this information would be sent to MB.

5. It is quite possible that the proposed RNA level mechanism is the microscopic mechanism behind strengthening of synaptic connections believed to be behind neuron level learning although also here new findings suggests that situation is not quite it has been believed to be (see `http://tinyurl.com/ybglebph`).

This did not say anything about cognition yet. TGD leads also to a view about mathematical correlates of cognition requiring profound generalization of the mathematical structure of theoretical physics. Real number field is tailor made for the description of the sensory world but how to describe the correlates of cognition. Here p-adic number fields come in rescue and in TGD framework one ends up to a unification of real physics and their p-adic analogs to what I call adelic physics (see http://tinyurl.com/ybepht6d and http://tinyurl.com/ybzkfevz).

3.6.4 Could also RNA and protein methylation of RNA be involved with the expression of molecular emotions?

Some time ago I wrote an piece of text [L48] (see http://tinyurl.com/ydhxen4g) about learning of slime molds [I14, I19]. The proposal was based on the vision inspired by the model of bio-harmony [L15, L52] and stating that harmony of music of light (and maybe of also sound) realized as 3-chords of dark photons with frequencies of 12-note scale expresses and creates emotions and that each harmony corresponds to a particular mood. The painful conditioning of the slime mold would generate a negative mood which would infect DNA and induce epigenetic change. This picture conforms also with the finding that RNA can induce learning of conditionings in snails [**?**] (see http://tinyurl.com/ycqxyeqk) [L48]. Slime mold does not have central nervous system but a natural guess would be that also synaptic learning involves similar mechanism.

One can ask whether also RNA and protein methylation could be involved with learning. If molecular moods correspond to bio-harmonies and if the conditioning by say painful stimulus involves a change of the emotional state of RNA inducing that of DNA, it must change some of the chords of the bio-harmony. Since bio-harmony is essential for communications by dark photons between dark proton triplets representing dark variants of the basic biomolecules and also between communications between bio-molecules and their dark variants, one expects that the change of the harmony occurs for all dark analogs of biomolecules and also for their ordinary biomolecules. Some chords represented by DNA-, RNA-, and tRNA codons, and amino-acids - briefly basic bio-molecules - would be affected in the change of mood.

The recent finding (see http://tinyurl.com/y9qsnfeo) that synaptic connections involve more methyl marks of RNA than other parts of neurons and that the RNA marks tend associated with genes coding for proteins associated with synapses provides support for this view that emotions expressed as modifications of the basic biomolecules. The emotional states would have epigenetic effects changing the gene expression and inducing learning as modification of synapses in turn modifying the behavior. This picture provides also a mechanism for the inheritance of epigenetic modifications: what would be inherited would be emotional states represented in terms of bio-harmonies the level of magnetic body carrying dark protons.

Some background about modifications of the basic biomolecules

To get a some perspective consider first some background about the modifications of the basic bio-molecules.

1. In the case of DNA epigenetic modifications (see http://tinyurl.com/kdd3qmp) affect mRNA and thus also protein expression. There are two basic mechanisms involved. Methylation of C nucleotide of DNA and protein modification for histone.

   Methylation (addition of CH_3 to N) of C nucleotide leads to a silencing of gene expression. Methylation occurs typically for CpG pairs and for both strands. Before embryogenesis demethylation occurs for the entire DNA (stem cell state) but cell differentiation means methylation of genes not expressed. In vertebrates 60-80 percent of CpG is methylated in somatic cells. CpG islands form an exception involving no methylation. Demethylation (see http://tinyurl.com/ybg3mz6v) as the reversal of methylation occurs either spontaneously or actively.

   The effects on gene expression can be also inherited to next generations. The mechanism of inheritance is poorly understood. The epigenetic change should be also somehow communicated to the DNA of germ cells but this seems impossible. The mystery is deepened because before embryogenesis demethylation occurs for the entire genome. It is difficult to

understand how the chemical storage of the information about methylation patterns to be transferred to the next generation is possible at all.

The TGD view about emotional expression inducing epigenesis by communications via dark photons between basic biomolecules and their dark variants suggests an elegant mechanism. What would be inherited would be the emotional states represented by bio-harmonies assignable to the dark variants of biomolecules.

2. In the case of pre-RNA post-transcriptional chemical modifications (see `http://tinyurl.com/y8c4w4mp`) - in particular methylation, are known to occur, and they affect RNA splicing rates and change the distribution of mRNAs and thus of proteins. The modifications affect also un-translated RNA (UTR) but not the protein translation from mRNA.

3. Protein modifications (see `http://tinyurl.com/jtczea5`) in turn affect the dynamics of proteins - in particular their properties as enzymes by affecting therefore the rates for various basic processes.

   As already noticed, protein modifications are important in epigenesis by histone modification. Wikipedia article mentions lys acetylization by adding CH_3=O group (see `http://tinyurl.com/yd2y7s2m`), lys and arg methylation (see `http://tinyurl.com/ybxgdwhz`), ser and thr phosphorylation, lys ubiquintination and sumoylation. For N-terminus (H_2 group in the start of protein) the process is irreversible and new amino acid residues emerge. Methylation in C terminus (O=C-OH end of protein) can increase chemical repertoire. Note that the methylation occurs at the ends of the protein just like it tends to occur in the case of RNA as will be found.

RNA modifications deserve to be discussed in more detail. This field of study is known as epitranscriptomics (see `http://tinyurl.com/y8c4w4mp`) . These chemical modifications does not affect protein expression except in the case that they affect the rates of various alternative pre-RNA splicing so that the distribution of alternative protein outcomes changes. Clearly, the effect is somewhat like the effect of mood on overall activity. There are also many other modifications of RNA (see `http://tinyurl.com/y8c4w4mp`). One of them is A-I de-amination which changes in RNA but does not affect protein expression.

The methylation of RNA is the most common and best understood modification of RNA.

1. The modelling of the methylation of both DNA and RNA is based on writer-reader-eraser model. Writing corresponds to methylation. Reading corresponds to attachment of enzymes involved in the splicing or protein synthesis with higher rate to methylated sites. Demethylation is example of erasing.

2. Methylation is known to occur for various variants of RNA (ribosomal rRNA, tRNA, mRNA, and small nuclear RNA snRNA related to metabolic machinery) after transcription. The biochemical modifications of RNA are called epitranscriptomes (see `http://tinyurl.com/y8c4w4mp`). N^6-Methyladenosine (m^6A) is the most common and best understood modification of RNA. m^6A tells that nitrogen in position 6 of adenosine (A) is methylated by adding group CH_3. m^6A sites are often located in the last exon near the end of mRNA, in untranslated RNA (UTR) at 3' end, and inside long exons.

   It has been found that 3 members of so called YTH domain protein family acting as readers have larger affinity to bind to methylated sites. One of them shortens the lifetime of mRNA after translation.

3. Methylation in general shortens the UTR (un-translated regions) of mRNA in its 5' and 3' ends (head and tail of mRNA)). One speaks of alternative poly-adenylation (APA, see `http://tinyurl.com/y7aratpv`) of the tail of the mRNA: poly-adenylation (PA) adds A-sequences to the end of mRNA affecting its dynamics: shortening of UTRs means shortening of PAs.

4. Methylation affects the rates in the dynamics of translation but does not affect the product of translation itself. A-sequences shields mRNA and during its life cycle its length is reduced somewhat like telomere (see `http://tinyurl.com/jpbkzzc`) consisting of a repeated

sequence TTAGGG and also shortening during the life cycle of DNA. APA affects rates for the dynamics of translation. Also stem loops of pre-RNA can be methylated and this can increase the rate of an alternative splicing and thus change relative rates of alternative gene expressions.

Methyl marks in synaptic connections from the TGD point of view

What inspired this piece of text was a highly interesting popular article "Methyl marks on RNA discovered to be key to brain cell connections" about methylation of RNA in brain (see `http://tinyurl.com/y9qsnfeo`). The research article [**?**] (see `http://tinyurl.com/ybg92nyd`) by Daria Merkuvjev *et al* has title "Synaptic N6-methyladenosine (m6A) epitranscriptome reveals functional partitioning of localized transcripts". The researchers isolated brain cells from adult mice and compared epitranscriptomes found at synapses to those elsewhere in the cells. At more than 4,000 spots on the genome, the mRNA at the synapse was methylated more often. In more than half of genes the epitranscriptomes were found in genes coding for proteins found mostly in synapses. If the methylation was disrupted, the brain cells did not function normally. It was concluded that the methylation probably makes signalling faster.

These findings conform with the idea about representation of molecular emotions as bio-harmony. Synaptic contacts are the places where emotions should be expressed to give rise to learning by conditioning realized in terms of changed synaptic strengths. If the communication between dark and ordinary biomolecules relies on resonance frequencies, it is is preserved only if the resonance frequencies for ordinary biomolecules are modified. Methylation would be one particular mechanism for changing some 3-chords of the harmony (in the simplest model only one of the 3 notes of 3-chord corresponding to A in various position). The methylations of DNA, RNA and proteins should also correlate if they are in common mood dictated by the bio-harmony.

3.6.5 How does brain predict future?

Quanta Magazine is a real treasure trove. The gem was at this time titled "*To Make Sense of the Present, Brains May Predict the Future*" (see `http://tinyurl.com/yb84wn7u`). The article gives links to various research articles: here I mention only the article "*Neural Prediction Errors Distinguish Perception and Misperception of Speech*" by Blank *et al* [**?**] (see `http://tinyurl.com/y7edd3v`) .

According to the article, brain acts as a prediction machine comparing predictions with what happened and modifying the predictions accordingly. Sensory perception would not be mere 3-D sensory time=constant snapshot as believed in last century but include also a prediction of future based on it that would be outcome of sensory perception and brain is able to modify the prediction by using the difference between prediction and reality.

In TGD framework one can go even further [L33] (see `http://tinyurl.com/yczv2o5b`). Sensory organs are the seats of sensory mental images constructed by repeated signalling between brain (maybe also magnetic body) and sensory organ using dark photons propagating forth and back with maximal signal velocity and contributing to the sensory input a virtual part. Nerve pulses would create by synaptic bridges connecting flux tubes to longer flux tubes acting as waveguides for dark photons to propagate. Sensory mental image would be essentially self organization pattern nearest to the actual sensory input. The percept itself would be artwork, a caricature selecting and emphasizing the features of sensory input important for the survival.

The term predictive coding used about the process reveals that the view about how brain achieves this relies on computational paradigm. This is one possible view. Personally I do cannot regard classical computation as a plausible option. A more neutral view relies on rather obvious assumption that that temporal sequences of associations giving rise to predictions. But how does this happen?

Neuroscientists speculate about deep connections between emotions and learning: the dopaminergic neurons are indeed very closely related to the neural reward system. If the difference between the predicted and actually perceived is large the reward is small - one might also call it punishment. "Surprise" would be rather neutral word to express it. Big discrepancy causes big surprise. The comparison of predicted and what really happened would be essential. This is was one of the first predictions of TGD and might apply to simple emotions but - as I have proposed - emotions such

as experience of beauty, compassion or love need not correspond to emotions need not be mere reactions.

The finding suggests a connection with the ideas about the fundamental role of emotions in learning. I have already developed this theme in this article.

1. The first finding made for snails [**?**] (see `http://tinyurl.com/ycqxyeqk`) was that RNA somehow codes the experience and induces epigenetic change at the level of DNA in turn inducing a change in behavior. The popular article " *Scientists Sucked a Memory Out of a Snail and Stuck It in Another Snail*" tells about the finding (see `http://tinyurl.com/y92w39gs`).

   This led to a TGD based model based on the notion of bio-harmony for music of dark photon triplets representing 3-chords predicting genetic code correctly. Music expresses and creates emotions: same would happen already at RNA level. DNA would get in the same mood and by resonating with the 3-chords of RNA music and changing its harmony/mood coded by resonance frequencies of nuclei, which would slightly change. Epigenetic change would take place as a consequence and change the genetic expression in turn changing the behaviour.

   This brings in something genuinely new: TGD based view about dark matter, realizations of genetic code by dark proton sequences defining the dark analogs of DNA, RNA, tRNA, and amino-acids at the magnetic flux tubes of magnetic body of living system plus realization of the genetic code.

   It must be emphasized that magnetic body is 4-D and corresponds to a preferred extremals connecting to two 3-surfaces at the boundaries of causal diamond. Hence the basic objects are deterministic time evolutions, analogous to programs or behavioral patterns. The sequence of associations assignable to percept could be seen as space-time surface, a predicted space-time time evolution.

2. Just a couple of days before writing this I learned about slime molds (see `http://tinyurl.com/ydc8gh4d`) , which are monocellulars, which contrary to expectations learn new behaviours [I14, I19]. Nervous system is not therefore necessary for learning. Emotional RNA could be at work also here.

3. RNA would be naturally also behind the learning in CNS as a change of synaptic strengths generating effectively different synchronously firing neuron groups representing mental images and new sequences of associations providing predictions. The mismatch between prediction and real percept would we represented in terms of dopamine concentration and this in turn would generate at RNA level emotion, which would be negative for mismatch and induce corresponding DNA emotion generating epigenetic change in turn changing synaptic strengths in turn changing the prediction as a sequence of associations regarded as temporal sequence in turn changing the behavior! Long sequence of causations!

Also the speculated unification of motor control and sensory perceptions is mentioned in the popular article. In sensory perception internal environment as a model for external environment is updated. In motor action it is external environment. Connection with arrow of time? Motor action as perception of changing environment where own biological body is part of environment. In TGD framework sensory perception and motor action would be time reversals of each other at the level of sensory mental images. This view is allowed by ZEO and encouraged by the discovery of Libet that volitional act is preceded by neural activity by a fraction of second.

Motor action would be generated by a negative energy signal to the geometric past which would correspond to mental images with reversed arrow of time in TGD inspired theory of consciousness. This duality would mean that in opposite time direction motor action would be a perceptions about say hand moving in desired direction! The counterpart of predictive coding would take care of comparisons and modifying the predicted "sensory percept" so that it corresponds to reality. This sounds strange but maybe the motor actions is just passive perception from the point of view of time reversed self!

Chapter 4

About TGD based view of neuron

4.1 Introduction

The inspiration for looking again at the TGD view about nerve pulse conduction [K79] came from email discussions with Jouko Alanko. I learned about the conduction of action potentials in the myelinated portions of axons, where ion fluxes assignable to the action potential do not seem to be possible, remains a mystery although 71 years has passed since the proposal of the Hodkin-Huxley model of nerve pulse conduction (`https://cutt.ly/ATvjVHD`).

J. W. Jacak proposes a model of saltatory conduction [?] (`https://cutt.ly/cTvj0db`) according to which action potential could propagate in plasmon-polariton condensate and the myelinited portions of length about $L = 100$ μm could behave like electric dipoles. This requires coherence in scale L and one might ask whether quantum coherence of plasmon-polariton condensed might be involved.

What makes this idea interesting is that plasmon-polaritons are known to form BEC condensates in the presence of energy feed as laser light. In the TGD framework this particular BEC formed in the presence of an external energy feed would represent one example of a much more general phenomenon in which the metabolic energy feed increases the values of h_{eff} for the system and keeps their distribution stationary. This would not be a stationary BEC but a BEC analogous to flow equilibrium. For instance, metabolic energy feed would give rise to a forced bio-superconductivity. An exciton-polariton condensate could be also present. However, to me the answer to the question whether this can give rise to an action potential remained unclear to me.

This inspired a careful reanalysis of the earlier TGD inspired visions of nerve pulse conduction [K79], EEG [K38, K81, K55, L76] and of brain based on the new view about pace-time, the notion of the magnetic body carrying $h_{eff} > h$ phases behaving like dark matter, and the zero energy ontology (ZEO) based quantum measurement theory extending to a theory of consciousness.

The TGD view about nerve pulse assumes that nerve pulse is a secondary phenomenon induces by a voltage modulation wave assignable to a generalized Josephson junction formed by lipid layers of the cell membrane for which Josephson frequency f_c is replaced by the sum $f_c + \Delta E_c$, where ΔE_c is the difference between cyclotron frequencies from transversal flux tubes at the different sides of the axon.

What propagates is the deviation of membrane potential, possibly below the critical value for the generation of action potential. There is no action potential in the myelinated portions and it is generated only in the unmyelinated portions of length about 1 μm and gives rise to chemical effects and would also communicate a signal to the magnetic body (MB) if the notion of generalized Josephson junction is accepted.

The model survived the Occam's razor with small modifications and became much more precise and led to more explicit formulation of the speculative generalization of the genetic code [L77].

An interesting challenge for the model is the discovery that the density of the voltage gated ionic channels in the dendrites of neurons is considerably lower for humans than for mammals. The general model suggests that the spatiotemporal patterns of Josephson radiation emitted by segments between nearby ionic channels or pumps define analogs of sentences of language having

nerve pulse as a punctuation mark analogous to the stop codon for DNA, then these sentences would be longer for humans, which could relate to the emergence of the human language capacity.

4.2 Neuron and brain according to TGD

The TGD view of the brain has evolved during the last 30 years and differs from the neuroscience based view in several aspects. The notion of MB carrying $h_{eff} \geq h$ phases behaving like dark matter and zero energy ontology (ZEO) predicts time reversal in ordinary ("big") state function reductions (BSFRs). BSFRs would be counterparts for motor actions and "small" SFRs following unitary time evolutions would be counterparts for sensory perception.

Josephson radiation communicates information from the biological body (BB) to MB and gives rise to EEG and possibly also its scaled variants. BSFRs at MB produce cyclotron resonance peaks, which would generate a feedback signal to the central nervous system (CNS) via genome and/or microtubules. These signals in turn induce oscillatory perturbations of the soliton sequence leading to secondary nerve pulses. This gives rise to a closed control loop BB-MB-BB.

The generalization of Nottale hypothesis [E2] states that one can assign to gravitational flux tubes gravitational Planck constant $\hbar_{eff} = \hbar_{gr} = GMm/v_0$, where G is Newton's constant, M is large mass - say Earth's mass or solar mass -, and m is mass of particle, and $v_0 \leq c$ is a velocity parameter [L43, L76, L83, L81] [K12]. The Nottale hypothesis, in particular the dependence of $\hbar_{gr}$ masses (more generally charges) is discussed from the point of view of Yangian symmetry implying polylocal conserved charges in [L79].

Nottale hypothesis conforms with the Equivalence Principle and implies universality in several senses. The cyclotron energies $E_c = \hbar_{gr} ZeB/m = ZeGMB/v_0$ for charged particles and gravitational Compton length $\Lambda_{gr} = GM/v_0$ are independent of the particle mass m. Cyclotron frequencies do not depend on h and Josephson frequency $f_J = ZeV/h_{gr} = ZeVv_0/(2\pi GMm)$ is inversely proportional to mass m just like f_c so that the ratio f_c/f_J is also universal in that it does not depend on the mass of the charged particle. Also the generalized Josephson frequency $F_J = \Delta f_c + f_J$ is universal.

Cell membrane as a (generalized) Josephson junction is an essential element and its ground state corresponds to a propagating soliton sequence. A perturbation reducing the membrane potential below the critical value for the generation of action potential replaces nerve pulse as a fundamental phenomenon and the soliton sequence would be present in all cell bodies but would not propagate as it does in the axons and dendrites. Neither would it generate a nerve pulse. The modulation is universal and the same for all charged particles. Frequency scale is however inversely proportional to the particle mass m and highest for electrons.

If the modulation is small, the cyclotron frequencies define the frequency scale and corresponding natural time scale for events at the MB. In the "endogenous" magnetic field $B_{end} \simeq 2B_E/5$, where $B_E \simeq .5$ Gauss is the nominal value of the Earth's magnetic field, tentatively interpreted as monopole flux part of the Earth's magnetic field the cyclotron frequencies of proton and electron are $f_c(e) = 6 \times 10^5$ Hz and $f_c(p) = 300$ Hz (assignable to the rotating shaft of ATPAse). Ions have cyclotron frequencies in the EEG range. For protons, a modulation by a nerve pulse of duration of few milliseconds would represent rather slow frequency modulation in the scale of $f_c(e)$. For protons and ions, the modulation would be a short ripple and presumably of no significance. Hence the nerve pulse could be significant only for the representation of the system provided by dark electrons.

This suggests that generalized Josephson radiation for B_{end} appears in various frequency scales characterized by cyclotron frequencies of electron, proton, and biologically important ions and that one can assign flux tubes of the gravitational part of magnetic body with various kinds of ions with characteristic frequency and time scales but universal cyclotron energies. Besides B_{end} also other values of B can be considereed and the model of bioharmony suggested that approximately correspond to frequencies of 12-note scale [L15, L56, L70, L77].

One can assign to elementary particles also a p-adic secondary time scale and for electrons this scale corresponds to .1 second assignable to the alpha band of EEG. Intriguingly, for u and d quarks this time scales if of the order of the millisecond time scale assignable to nerve pulse.

4.2.1 TGD based view about nerve pulse conduction

In the TGD framework, nerve pulses would be induced by more fundamental dynamics of the neuronal membrane acting as a possibly generallized Josephson junction between superconductors associated with the lipid layers of the membrane. Also the ordinary cell membrane would give rise to this kind of Josephson junction. The sequence of Sine-Gordon solitons propagating along the axons would represent the resting state of the axon and its perturbations would define the fundamental dynamics. An interesting question is, how this sequence relates to the time crystals now in fashion.

At the microscopic level, this Josepson junction would decompose to Josephson junctions associated with the membrane proteins acting as ion channels.

1. In the microscopic picture, the axon is analogous to a sequence of penduli associated with the membrane proteins acting as Josephson junctions and during nerve pulse as ion channels.

   The Sine-Gordon soliton sequence is mathematically analogous to a sequence of rotating penduli such that the phase difference between subsequent penduli is constant. This gives rise to a constant phase velocity v. Perturbation corresponds to the local transformation of the rotation to oscillation so thay frequency parameter is reduced. The perturbation propagates with the same velocity as the solitons of the soliton sequence.

   If the perturbation takes the membrane potential below critical value, action potential is generated and in myelin free regions the optimum velocity v is identifiable as the conduction velocity v_c of the nerve pulse. For $v \geq v_c$, the physiology is too slow to react to the perturbation.

2. There is no need for action potentials in the myelinated regions. This would lead to considerable energy savings reducing the energy feed by factor 1/100 as the ratio of the lengths of Ranvier nodes and myelinated portions.

   The perturbation of the soliton sequence could propagate freely since it would not be forced to move at the same velocity as the action potential restricted by physiological constraints. This would increase the propagation velocity and apparent conduction velocity by a factor of order 100 and give rise to the dramatic difference between vertebrates having myelinated axons and invertebrates without them.

3. Action potentials would be generated only in the unmyelinated Ranvier nodes of length about 1 mm between myelinated portions of length about 100 μm. This allows considerable savings in metabolic energy. Overcritical modulation would generate an action potential at positions of voltage gated ion channels inside the Ranvier node.

4. The TGD based model would solve the still-unsolved problem about how action potentials are conducted in the myelinated portions of axon. Saltation is the proposed mechanism but is plagued by many blatant conflicts with empirical facts [?] (`https://cutt.ly/GTvjEJo`). For instance, the thickness of myelinated axons is not enough to guarantee high enough conduction velocity.

   The fact that the splitting of the axons does not prevent the transfer of the action potential between myelinated portions, which suggests that there is a deeper propagation type phenomenon involved. In the article it is proposed that the saltation could be understood as a wave packet in plasmon-polariton condensate and that the entire myelinated portion effectively acts as a dipole.

   In the TGD framework there would be no conduction of nerve pulses inside myelinated regions but propagating waves in plasmon polariton type condensates (Ca waves?) could induce perturbations of propagating soliton sequence assignable to cell membrane as a generalized Josephson junction allowing communication of chemical "sensory" data to magnetic body (MB) of the system.

What is the function of neurotransmitters?

In the standard picture, the neurotransmitters would make possible propagation of a membrane voltage modulation through synaptic gap by building a bridge. This picture looks rather reasonable

in the context of standard neuroscience.

What the function of neurotransmitters could be in the TGD framework? TGD allows several guesses for what happens at synaptic contact.

1. Flux tubes, or rather, the massless extremals (MEs) [K70, K8]) associated with them act as wave guides for classical gauge fields. Neurotransmitters at the synaptic contacts would connect pre- ja postsynaptic flux tubes to longer flux tubes. This would make classical communications possible inside the brain and generate classical coherence. There would be no quantum coherence at the level of ordinary matter but the classical coherence would be induced by the quantum coherence at the level of MB.

   At the level of MB the neurotransmitters would induce the increase of the scale of quantum coherence and h_{eff} could increase. h_{eff} and therefore the scale of quantum coherence tend to be reduced spontaneously so that it can last for some average time τ. Therefore $L = v \times \tau$ gives an upper limit for the average coherence scale at the level of CNS. The higher the conduction velocity v, the larger the size of the coherence regions. For $v = 100$ m/s and $\tau \simeq 1$ ms, one would have $L = .1$ m, the size scale of the human brain hemisphere. In the TGD view, the high conduction velocity would not be a prerequisite for high rate of communications in the brain but for the formation of large enough coherence regions.

   TGD also suggests that the bridges at junctions serve as relays making possible communications to the MB of a system consisting of pre- and postsynaptic neurons.

2. In this framework, the difference between vertebrates and invertebrates would not reflect the different rates of information processing but the different sizes of coherence regions and of the associated quantum coherence regions at the level of MB, which should be for vertebrates roughly by a factor 100 larger than for invertebrates.

   Note however that octopus (see `https://cutt.ly/cTvh3yD` and `https://cutt.ly/zTvh5Ir`) is is a highly intelligent invertebrate. In particular, it also has EEG. Octopus CNS has several centers analogous to the brain but there are no somatotopic mappings of sensory data providing a representation of the entire organism or even part of it. These features could be understood as reflecting the smaller size of the coherence regions at the level of the CNS.

3. The (possibly generalized) Josephson radiation communicated to MB from both unmyelinated and myelinated portions of the axon would create a sequence of cyclotron resonance peaks at flux tubes of MB. Resonance is obtained when the frequency modulated (generalized) Josephson frequency coincides with the cyclotron frequency at the flux tube of MB which can vary along the flux tube.

   The sequence of resonance peaks transforms the Josephson radiation to an analog of nerve pulse sequence and yields a feedback communicated via genomes and/or microtubuli to the postsynaptic neuronal membrane by transversal flux tubes. The outcome would be oscillations of the membrane potential perturbing the soliton sequence and possibly generating nerve pulses so that a closed control loop would be obtained. This communication to MB would correspond to EEG and possibly existing fractally scaled analogs of EEG.

   The communication of Josephson radiation followed by SSFR or BSFR is analogous to Fourier transform. The continuous temporal pattern of Josephson oscillations is transformed to a sequence of resonance peaks analogous to a sequence of nerve pulses defining a sequence of time differences.

4. This picture suggests that the information processing occurs at the level MB. How the response of MB to this sensory input is generated? The simplest option is that it is realized as a BSFR inducing time reversed time evolution just like raising the finger in the experiments of Libet. No specific mechanism would be needed.

5. For the ordinary Josephson junctions, the quantum coherence would be lost during action potential and the idea about small modulation of Josephson frequency does not make sense. This need not be the case for generalized Josephson junctions. The generalized Josephson frequency F_J is the sum $F_J = \Delta f_c + f_J$ of terms consisting of the difference Δf_c of cyclotron

frequencies for transversal flux tubes at both sides of the membrane and of Josephson frequency f_J , which would be small correction giving rise to modulation which is larger than in absence of nerve pulse.

If only ordinary Josephson junctions are present, the role of nerve pulse would be passive and purely chemical. Nerve pulse activity would affect the chemistry and would be essential in motor actions and in the long term modulation of brain structure and of function and behavior, say by inducing long term potentiation.

If MB is there, it would look natural for it to participate also in the long term modulation of brain function and behavior so that the communication of nerve pulse patterns to MB requiring generalized Josephson junctions looks a more attractive option.

4.2.2 Brain as a factory of standardized mental images

According to an earlier view, the brain would be a factory of standardized mental images. They would be produced by a quantum counterpart of pattern recognition involving virtual sensory input to sensory organs. How does the new view relate to this picture?

Earlier view

TGD leads to the proposal that nerve pulses do not transfer information inside the brain. The information about nerve pulse pattern could be communicated to MB if the notion of generalized Josephson junction makes sense as a modulation of the frequency F_J of generalized Josephson radiation containing a contribution proportional to membrane potential. This does however not seem absolutely necessary.

1. The starting point of the TGD based model of the brain is the idea that biophotons are ordinary photons produced from dark photons. There are indeed indications for the role of biophotons in brain functioning. This leads to the idea that dark photons and classical em fields propagating along massless extremals (MEs) parallel to magnetic flux tubes in the scale of brain are essential for the communications inside brain and that nerve pulses serve as relays connecting pre- and postsynaptic flux tubes to larger structures.

2. Also connections to much larger MBs are possible and could even give rise to communications allowing to exceed the limitations due to finite speed of light since signals could be time reflected by BSFR from very distant objects. The occurrence of BSFR is assumed quite generally in the new view.

3. Even BSFRs, the fact that light velocity dramatically exceeds the velocity of nerve pulse conduction would make possible virtual sensory input from the brain (or from MB via brain) to sensory organs as ordinary dark photon signals. This would make possible iteration producing standardized mental images. REM dreams serve as a support since they could be regarded as reflecting virtual sensory input from MB.

The open problem of this picture is that detailed mechanisms for the information processing at cortex or MB and for the generation of virtual sensory input are missing. Zero energy ontology (ZEO) [L63] [K115] could automatically provide these mechanisms.

The modified view

In the new view the signalling between parts A and B of brain (and body) would always occur in scales via an appropriate layer of MB as A$\rightarrow$ MB $\rightarrow$ B rather than directly as A$\rightarrow$B and involve BSFR at MB.

The BSFR at the level of MB would be followed by the step S$\rightarrow$ MB (S denotes sensory organ) inducing a virtual sensory input MB$\rightarrow$S via a signal via genomes of neurons of axon or microtubuli.

1. Genomes and/or microtubuli would receive the cyclotron radiation induced by a sequence of resonance peaks at MB and by stochastic resonance would transform this sequence to

oscillations affecting the membrane potential. The step MB→S would be a time reversal for the transformations of the Josephson photon signal to resonance peaks in the step $S \to MB$.

Remark: This picture explains why we can remember our dreams although we remember nothing about the sleep state. The natural assumption is that the sleep state corresponds to a change of the arrow of time by BSFR and that we cannot remember anything about this period. We remember dreams and this can be understood as a partial wake-up of the brain by another BSFR giving rise to the standard arrow of time. The change of the arrow of time at MB for a part of the brain would give rise to a virtual sensory input at some sensory organs and to REM dream.

2. MB has a layered onion-like structure involving several scales and the communications in shorter scales as communications $BB \to MB \to MB$ occurring via BSFR would be fast and have the same effect as classical communications. In longer scales involving layers of MB of size of order Earth, light velocity would become a problem, and the time reversal of BSFR could overcome this problem. One can even consider sizes of MB so large that the barrier due to finite light-velocity is overcome.

3. Brain can be seen as a factor of standardized mental images also in this picture. Communication steps between brain (and possibly MB of brain) and sensory organs are only replaced with the steps S→ MB → S.

   One can also consider the possibility $S_1 \to$ MB→ S_2 making possible quantal associations and synesthesia. Also sensory motor associations as an analog of synesthesia becomes possible.

Is the new picture consistent with the earlier view?

Is the new view about the brain as a factor of mental images consistent with the earlier view? Zero energy ontology (ZEO) implies that classical physics is an exact part of quantum physics so that also BSFR must have classical correlates.

In ZEO, zero energy state is a superposition of classical deterministic time evolutions - space-time surfaces which are preferred extremals - having 3-D ends at the boundaries of a causal diamond (CD).

1. The passive boundary of CD is not affected during the sequences of "small" SFRs (SSFRs) and also the 3-D states at it are unaffected (analog of Zeno effect). The active boundary of CD is shifted and the size of CD increases at least in statistical sense during the sequence of SSFRs. Also the states at the active boundary are affected in SSFRs.

2. In BSFR, the roles of boundaries of CD are changed and the new zero energy zero energy state as pair 3-D states (or perhaps their superposition) is a superposition of time reversed time evolutions beginning from the final state in 3-D sense (note that holography is almost exact). The strange looking experimental findings of Minev *et al* [L57] and Libet [**?**] support this picture [L57]. This implies that BSFRs look like deterministic classical time evolutions for times assignable to the final state in 3-D sense.

3. Quantum classical correspondence is an essential element of TGD and implied by ZEO. Classical signals defined by what I call topological light rays (massless extremals, MEs) propagating with light velocity define a subset of classical correlates for what happens in BSFRs. The MEs would be parallel to flux tubes and signals would propagate along them to sensory organs and effectively give rise to the virtual sensory input.

   The next BSFR would re-establish the original arrow of time and give rise to the modified sensory input from sensory organ (S) to the brain as nerve pulse patterns and oscillations of membrane voltage. The iteration of the loop S→ MB → S would give rise to standardized mental images in analogy with the pattern recognition.

   Therefore one can say that the earlier picture is consistent with the new view if it is interpreted in terms of classical correlates.

There are several views about what memories are and one can invent an endless variety of representations of memories. As a matter, in the TGD framework one cannot separate representations of realities from the realities and conscious representations are everywhere.

4.2.3 How information is represented at the level of MB?

The basic question is how information is represented at MB. Computationalists assume analog of computer memory but in the TGD framework the representation as conscious repetitive processes looks more appropriate.

Memories as behaviors

Neuroscientists understand memories as behavioral patterns realized statistically as connections between neurons. Conditioning and associations as behaviors are realized in terms of strengthening of the synaptic contacts between post- and presynaptic neurons. This gives rise to neural networks.

In the TGD framework MB would realize these networks as flux tube networks at higher level and induce the counterparts of these networks at the level of BB (CNS). The connections A-B between nodes would be via MB as connections A-MB-B. If the generalization of Josephson junction is accepted, MB would actively control long term potentiations and development of behaviours.

The communication of the perturbations of propagating Sine-Gordon sequence associated with the axonal membranes and stationary Sine-Cordon lattice associated with the cell membrane would define one particular representation.

Memories as conscious mental images

Conscious information can be represented as conscious mental images defining temporal and spatial patterns.

1. Episodic and sensory memories are this kind of memories, kind of re-experiences. This kind of patterns would correspond in the TGD inspired theory of consciousness mental images as sub-selves, living entities having analogs of wake-up and sleep periods. After images provide a good example. They would be born in BSFR and die in the next BSFR and disappear from consciousness of self. They would however live with an opposite arrow of time during their sleep period.

2. Short term memories and perhaps also long term memories could be analogous to repeating after images. The loop BB-MB-BB from axon to magnetic flux tube and back could create a repeating nerve pulse pattern accompanying a similar repeating pattern of membrane potential oscillators modulating the frequency of the Josephson current. One can wonder whether this kind of representation applies for all time scales as memory spans.

Criticism of the computationalistic view about data representation and data storage

Computationalistic view about memory interprets memory as a sequence of symbolsm carved in stone. One can argue that the mathematical complexity of the sequence serves as a measure for the information carried by the sequence. This however does not tell anything about the information itself and a more approprite interpretation is as complexity.

As such the symbol sequence carries no conscious information. One can invent an endless number of various physical representations. How the physical realization is "read" to conscious experience remains however unsolved. Reading ordinary text induces a conscious experience in the reader and one could say that the experience tells what the information coded by the text is. The text has different meaning for different readers or no meaning at all.

Conscious information must be assigned to temporal dynamic patterns but they are not dynamical in the classical sense of the word. State function reduction (SFR) as a moment of consciousness would be the basic building brick for these patterns and since SFR replaces the quantum universe with a new one, one must give up the idea that deterministic dynamical patterns with respect to geometric time could carry any information as such. One can assign to them a measure of complexity, say as the dimension and structure of extension of rationals associated with the space-time region, but no information.

TGD based model of the genetic code

The TGD inspired model of genetic code based on the notion of bioharmony allows quite a dramatic generalization of the genetic code and suggests a radically different view about representation of information and its communication and even about how living matter functions.

1. DNA is often regarded as a sequence of letters and the 64 codons represent 6 bits of information. In this view, genes would correspond to bit sequences and be analogous to computer programs. Transcription to mRNA translated to proteins would be reading and printing of this information.

2. In the TGD framework, the notion of genetic code generalizes. These entities have magnetic bodies carrying dark matter which provides the fundamental realization of the genetic code. Chemical code would be a secondary realization.

   The flux tubes parallel to DNA strands are assumed to realize genetic codons as states of dark proton triplets [L15, L70]. The communications between DNA, RNA, tRNA, and amino-acids are realized in terms of dark photon triplets also realizing genetic code as 3-chord music of light one might say. The three dark protons/photons form a single quantum coherent unit.

   Bioharmony would correspond to what might be identified as the holistic emotional aspect of intelligence not taken into account in computationalism whereas codons as 6-bits would correspond to a reductionistic local aspect of intelligence.

   This idea generalizes further. Also genes can be realized as quantum coherent units both in terms of dark N-protons and N-photons analogous to Bose-Einstein condensates.

3. The formation of dark N-protons and N-photons relies on a universal number theoretic mechanism for the formation of bound states by what I call Galois confinement. At the M^8 level the mechanism has a simple description. The momenta of quarks at the fundamental level are algebraic integers in the extension of rationals defined by 4-surface of M^8 mapped to H by $M^8 - H$ duality.

   This makes possible number theoretic universality, meaning that the momenta of quarks defining the quantum state and corresponding to a subset of points in $X^4 \subset M^8$ make sense also for the extensions of p-adic numbers defined by the extension of rationals. The subset of points of X^4 carrying quarks defines the physical set as a cognitive representation.

   Bound states of quarks would have by periodic boundary conditions momentum components, which are ordinary integers for a suitable momentum unit defined by the size scale of CD. This means Galois confinement. Fermi ball with each point with momenta having integer components is a maximal cognitive representation.

4. This gives rise to a hierarchy of Galois confinements in which the Galois non-singlets of a given level can form singlets at the next level. This generalizes also to wave functions in the space of momenta with algebraic integer valued components which would be Galois singlets for physical states.

   This would define a universal mechanism for the formation of bound states. Stability however requires that the energy of the bound state is smaller than the sum of the energies of composites. Dark N-codons and dark 3N-photons would represent special cases of these entities.

This picture also leads to a vision about communication and control and information processing in living matter.

1. 3N-(cyclotron)-resonance between dark proton N-triplet representing DNA, RNA, tRNA or amino-acids by dark photon N-triplet makes possible communications in which only identical codon sequences get in contact. Frequency- and energy resonance are possible if the values of h_{eff} are the same and only energy resonance if they are different.

   Resonant communication by dark photons, possibly transforming to dark photons with a different value of h_{eff} or to ordinary photons, gives rise to association sequences analogous to those appearing in computer language LISP.

2. Even this is not enough. In the TGD framework the spectrum of possible genetic code expands dramatically and DNA and basic biomolecules could be only a special case.

   The hyperbolic space realized as a mass shell at the level of M^8 would define an infinite number of tessellations [L77]. Perhaps the simplest tessellation, known as icosa-tetrahedral tessellation also involving octahedrons, realizes genetic code in the model of bioharmony. The projection of this tessellation induces a tessellation at 4-surface of H mapped to $M^4 \times CP_2$ by $M^8 - H$ duality. The induced tessellation is. analogous to the quasicrystal, which is also obtained as a projection of a higher dimensional lattice.

   This tessellation could assign variants of genetic code which can be, not only 1-, but also 2- and 3-dimensional. For instance, the cell membrane could provide a 2-D realization of genetic code. Genetic code could be present everywhere, even outside biology.

3. Could the generalized Josephson radiation consisting of dark 3N-photons have an interpretation as N-codons analogous to 2-D variants of genes so that the propagation of the perturbation of the soliton sequence would be like reading a "sentence" for MB serving as a listener? Could the myelinated portions of axons define this kind of generalized genes? Could the nerve pulse at Ranvier nodes define the analog of punctuation mark ending a "sentence"?

   This proposal is actually inspired by the TGD inspired model for the emergence of human language [L129, L130].

4.2.4 Model for how information is communicated to MB

Since MB represents a higher level in the self hierarchy, the above considerations suggest that the communication of information from BB to MB is analogous to speech or written language.

Could Josephson radiation patterms assignable to the myelinated portions of axon define "sentences"?

The intuitive feeling is that the decomposition of axon to myelineated portions and the Ranvier modes generating action potential should have some meaning from the point of view of communications from BB to MB. Since MB should provide a higher level cognitive representation of the sensory data, the natural idea is that Josephson radiation patterns assignable to the myelinated portions of axon define analogs of sentences and that the Ranvier nodes and the associated action potential defines an analog of punctuation mark. BB would be talking to MB and MB would be bresponding.

For generalized Josephson junctions also nerve pulse patterns are communicated to MB and an interesting question is whether they could be analogs of punctuation marks or of stopping codons for DNA and divide the signal to MB to what might be regarded as "sentences".

1. If one assumes generalized Nottale's hypothesis, the nerve pulse durations of about ms would be longer than the cyclotron frequency $f_c = 6 \times 10^5$ Hz of electron in B_{end} by a factor of order 10^3 and the propagation along myelinated portion would last about $T = 1$ μs, which is of the same order of magnitude as $T_c = 1/f_c(e)$ so that the interpretation is not plausible. Rather, slow modulation of generalized Josephson radiation for electrons looks a more plausible interpretation.

2. For ions, T is too short as compared with the cyclotron time scale T_c for B_{end}. Ions could correspond to slow oscillations of the membrane potential above $f_{J,c}$. Fast Calcium waves have velocities 10-30 μm/s. Slow Calcium waves propagate with velocity about $v \sim 1$ μ/s (`https://cutt.ly/tTWrTrA`). In these cases, one would have $T \in 3.3 - 10$ s and $T = 100$ s.

3. The propagation velocity assignable to the perturbation of the soliton sequence need not be the same as that for the soliton sequence and it could depend on the ion to which the perturbation is associated. In this case, the interpretation of the Josephson radiation pattern as a "sentence" of text and of the action potential at the ion channel as an analog of punctuation mark can be considered.

4. More generally, various ions could induce propagating oscillations of the membrane potential parameterized by frequency and velocity, each in their own frequency scale, and these oscillations would correspond to a modulation of F_J giving rise to cyclotron resonance peaks at the gravitational MBs of dark ions. This would define a sensory representation of the chemical dynamics at various layers of MB.

   The ion waves could correspond to waves assignable to plasmon-polariton BEC condensates proposed in the article of Jacak [**?**] but with $h_{eff} \leq\leq h_{gr}$. Plasmon corresponds to an oscillation of the density of plasma particles. In units with $c = 1$, the plasma frequency for free charges is given by $f_P = Ze\sqrt{n/m}/2\pi$, where n is number density of the ions, Ze is ion charge, and m is ion mass. Usually only electrons are considered because they are the most important charged plasma particles.

   Surface-plasmon-polariton appears at the surface of metal in contact with dielectric (such as air) and can be seen as a quantum superposition of electromagnetic field propagating in dielectric and a surface plasmon at the plasma surface. Plasmon-polariton BEC condensates as analogs of flow equilibria could be driven by metabolic energy feed. It has been proposed that plasmon-polariton BECs appear also in cell membranes [I30] (`https://cutt.ly/LTWbH13`). These BECs might form a bridge between BB and MB.

Model for the flux tubes receiving the Josephson radiation

It is interesting to consider models for the perception of the Josephson radiation at the flux tube or of a bundle of flux tubes having interpretation as many-sheeted space-time but regarding CP_2 instead of M^4 as fixed space-time.

Consider first a model based on single flux tube with a varying thickness.

1. The magnetic field strength at the flux tube scales like the inverse of the area S of the flux tube proportional to the radius squared. The variation of the flux tube radius R therefore defines a range of resonance frequencies and different momentary Josephson frequencies correspond to special points of the flux tube and single point if the flux radius is monotonically increasing.

2. This would translate the temporal variation of frequency modulated generalized Josephson radiation to a motion of the resonance point along the flux tube and could give rise to a conscious experience as a sensation analogous to a moving point of touch. If BSFR accompanies the resonance, the arrow of time would change at the point considered and give rise to wake-up at the resonance point.

3. For the myelinated regions the motion is smooth in the entire frequency interval. For the unmyelinated portions, one can divide the frequency range to two intervals corresponding to the frequencies above the critical frequency $f_{c,c}$ for the generation of the action potential and those below $f_{c,c}$. One would have a smooth motion for over-critical frequencies $\Delta f_c + f_{J,crit}$, where $f_{J,c}$ is the critical value of Josephson frequency below, which action potential is generated. For sub-critical frequencies a rapid motion from $\Delta f_c + f_J$ to $\Delta f_c - f_J$ and back scanning over the entire flux tube portion and back occur in unmyelinated regions.

   A possible interpretation is that this defines the analog of punctuation mark for the signal as analog of written "sentence" defined by the input from the unmyelinated region.

4. For $v = 10^2$ m/s and $L = 100$ μ m, the duration $T = L/v$ of the "sentence" associated with the myelinated portion of axon would be about 1 microsecond. Interestingly, the cyclotron frequency of electron in the "endogenous" magnetic field B_{end}, proposed to correspond to the typical value of the field strength at the monopole flux tube contributing to the Earth' magnetic field, is 6×10^5 Hz. For an unmyelinated portion of axon of length about 1 μm the velocity is roughly 1 m/s and the duration would be roughly 1 microsecond and roughly the same. The duration of nerve pulse is measured in milliseconds and is considerably longer so that the natural interpretation is as a modulation of Josephson frequency assignable to electron.

5. As already explained, if the perturbations of the membrane potential propagate slowly as Ca waves do, then the Josephson radiation pattern for ions could define "sentences" for the myelinated portions of axon and Ranvier node could play the role of a punctuation mark.

One can also consider a model based on a bundle of flux tubes such that each flux tube has a constant thickness and single cyclotron frequency. The flux tubes would be like pipes of an organ and the incoming Josephson radiation would serve as an organist. The bass register of the organ would be activated during the nerve pulse and nerve pulse would give rise to forth-and-back arpeggio between $F_{J,max} = \Delta f_c + f_{J,c}$ and $F_{J,min} = \Delta f_c - f_{J,c}$.

4.3 Humans are different

The popular article in Medicalxpress (`https://cutt.ly/2TvhXVE`) tells about highly interesting observation described in the Nature article "Allometric rules for mammalian cortical layer 5 neuron biophysics" by Mark Harnett [**?**] (`https://cutt.ly/8TvhMej`).

4.3.1 The volume density of voltage gated channels in human brain is much lower than for other mammals

The finding is that the density of voltage gated channels in the human brain is dramatically lower than in other mammalian brains. The neuronal system studied was layer 5 pyramidal neurons. Dendrites of these neurons were considered. Densities of voltage gated channels per neuron volume and per brain volume were studied. The ion channels studied were Na and K channels. The channels considered are ion pumps and need metabolic energy.

10 mammalian species were studied so that cortical thickness and neuron size were the varying parameters. As the neuron size increases, the density of neurons decreases. The first finding was that the density of ion channels for the neuron increases as the neuron size increases. The density of ion channels per brain volume was however found to be constant.

Humans were found to be an exception. The density of the channels per brain volume is dramatically reduced. The proposed interpretation is that this reduces the amount of metabolic energy needed to generate action potentials and the metabolic energy is used for other purposes.

Before continuing, it is good to recall some basic facts about neurons. Synapses (`https://cutt.ly/GTvjyFp`), dendrites (`https://cutt.ly/KTvjo7J`), and myelination (`https://cutt.ly/ZTvjdm1`) are the basic notions needed if one tries to understand these findings. It is enough to notice that most synaptic contacts are between axons to dendrites but that almost any other combinations are possible. Myelination occurs mostly for axons and only rarely for dendrites. The dendrites of the excitatory pyramidal cells studied in the article are profusely decorated with dendritic spines.

Could the TGD view about the brain allow us to interpret these findings? Why would the density of the voltage gated ionic channels be smaller for (at least) pyramidal dendrites? How could this relate to the evolutionary leap leading to the emergence of humans?

4.3.2 Possible interpretations for the reduction of the density of the voltage gated channels in humans

What could the reduction of the density of voltage gated channels mean? Why would the distances between voltage gated channels be longer for humans and what does this imply?

Recall first the basic ideas of the TGD based model of the nerve pulse.

1. The TGD inspired proposal is that humans differ from other mammals in that the value of h_{eff} involved is considerably larger for some neurons. The MBs of neurons would form an evolutionary hierarchy as also genes. In fact, the TGD inspired model for the generation of language [L129, L130] assumes that the value of h_{eff} for the MBs of language genes is considerably larger than for other genes.

2. The average distance between voltage gated ionic channels defines a spatial resolution scale and is a good candidate for the minimum wavelength λ assignable to a signal propagating along the dendrite. For an ordinary photon, λ defines energy, which must be above the thermal energy at physiological temperatures. This minimum energy is rather near to the minimal energy of the ordinary Josephson photons associated with membrane potential (about .05 eV) and the corresponding wavelength is 14.8 μm.

3. Nerve pulses [K79] are induce by perturbations of oscillating Josephson current, which in the rest state corresponds to a propagating sequence of Sine-Gordon solitons mathematically analogous to a sequence of rotating gravitational penduli. Nerve pulse corresponds to a perturbation, which kicks some penduli from rotational to an oscillating motion and this perturbation propagates along the axon with the same velocity as nerve pulse.

4. For generalized Josephson junctions, the Josephson radiation is frequency modulated by nerve pulse patterns. Also the spatial pattern of Josephson radiation characterized by the density of voltage gated ionic pumps along the flux tube contains information. The density of voltage gates, whose transversal flux tubes act as Josephson junctions characterizes the length scale resolution of the spatial variation at the receiving part of MB, say magnetic flux tube. MB receives a collection of Josephson radiation signals from the points of axons containing a voltage gated channel.

This allows us to consider two different but not mutually exclusive explanations for the finding.

1. The spatial resolution of the percept produced at MB by Josephson radiation would be reduced for humans. This need not be a drawback since it could be also understood as an abstraction. High spatial resolution would be needed only for local percepts in the scale of neuron soma. On longer scales it would mean generation of useless information and metabolic energy waste.

   The natural guess is that the resolution scale is proportional to $\hbar_{eff,B}$ at intra-brain flux tubes in turn proportional to $\hbar_{eff,MB}$ for the flux tubes at the MB of brain having quantal length scales much longer than brain size. The range of variation of the spatial resolution could correspond to the variation of ordinary photon wavelengths between visible wavelengths (of order μm) and IR wavelengths of order 14.8 μm. Note however that the lengths of myelinated portions are about 100 μm.

2. Suppose that Josephson radiation patterns associated with the myelinated portions of axon define "sentences" and the unmyelinated portions define punctuation marks ending these "sentences" by a nerve pulse. Does the notion of "sentence" make sense also for dendrites?

   At least in the case of humans, having a reduced volume density of ion channels, this picture might generalize also to dendrites, which are usually un-myelinated since the myelination is not needed since the dendrites are typically short as compared to axons. If so, the average distance between two ion channels would define length and duration for a "sentence".

   For other mammals than humans, the "sentences" would be very short or the notion of "sentence" would not make sense at all (the spatial extent of the perturbation of the membrane potential would be of the order wavelength of the soliton). Could this reflect the emergence of language in humans? MB would not only receive long "sentences" but also send them back as control commands inducing motor actions and virtual sensory input.

3. If the communication between pre-and postsynaptic neuron occurs via MB, dendrites would receive "sentences" from the MB of the presynaptic neuron as a feedback. If generalized motor action is in question, BSFR and time reversal would be involved. The action potentials propagate along axons in a single direction, which would reflect a fixed arrow of time. Does the reversed arrow of time imply that the action potentials along dendrites propagate outwards from the cell body?

   According to Wikipedia (`https://cutt.ly/9TnRDo4`), dendrites indeed have the ability to send action potentials back into the dendritic arbor. Known as back-propagating action potentials, these signals depolarize the dendritic arbor and provide a crucial component toward synapse modulation and long-term potentiation. Furthermore, a train of back-propagating action potentials artificially generated at the soma can induce a calcium action potential (a dendritic spike) at the dendritic initiation zone in certain types of neurons.

4. Dendrites are usually unmyelinated. This conforms with the fact that dendrites are much shorter than axons so that myelination is not needed. Myelination would also restrict the

number of synaptic contacts. Myelinated dendrites have been however found in the motochords of frog (`https://cutt.ly/HTnmqOi`) and in the olfactory bulb (OB) of some mammals, for instance mouse (`https://cutt.ly/ITnmC1d`). Their fraction is small.

Olfactory system (OS) is very interesting in this respect since it represents the oldest parts of CNS. The axons from the nasal cavity to the olfactory bulb (OB), where odours are thought to be processed are unmyelinated as are the axons of invertebrates in general. The axons from the olfactory bulb (OB) to the olfactory cortex (OC) are myelinated. This conforms with the idea that OB corresponds to the oldest part of OS. The TGD interpretation would be OB sends the results of analysis to OC via MB as "sentences".

OB also can have a small fraction of myelinated dendrites implying a reduction in the number of synaptic contacts. The rule "A→B" → "A→ MB→ B" suggests that there is an MB between olfactory epithelium and OB and that some analysis is performed at MB. If so, the myelinated dendrites would correspond to input from MB as long "sentences".

Chapter 5

Are dark photons behind biophotons?

5.1 Introduction

I have written already earlier about bio-photons [K74] 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 [L12] [L12] 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 [L12] [L12] 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 [**?**] [L11] 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.

5.1.1 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 [I37, I43]. Also Roeland van Wijk [**?**] 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` [I1]. 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 [I1, I29]. 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 [I35, I15]. 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 [I15] 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`) [I1] 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 [I7].

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 [I27], to Becker's DC currents [**?**] and the related TGD inspired model discussed in [L8]? Could bio-photons relate to vision and imagination? Bischof [**?**] and Bokkon *et al* [**?**, **?**, **?**, **?**, **?**] have made several proposals in this respect. What is behind the correlation between EEG and bio-photons (for which multiple sources of evidence exist - [**?**, **?**, **?**] - or that between the changes in bio-photon emission in meditative [**?**] and qigong practices [**?**, **?**, **?**, **?**]? 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`, [**?**]). The purpose is to build a more detailed view about bio-photons relying on ideas represented already earlier [K55, K74].

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.

5.1.2 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 [K70]). 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 [K49], 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 [I27] 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 [I27]. 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 [K2] and with the vision about various representations (sensory, motor, memory,..) [L12]).

   (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 [I16] 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 [**?**] but visible photons emerge from right hemisphere [**?**].

   (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 [I15] 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.

5.1.3 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 [I49]. 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) [L11].

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 [K55] (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` [L14].

5.2 Bio-Photons In TGD Universe

I have discussed already earlier the identification of bio-photons in TGD framework [K16, K74].

5.2.1 The Origin Of Bio-Photons In Standard Physics Framework

The are several proposals for the source of bio-photons: for instance cell membrane [I25], DNA [I35], mitochondria [I39], linear molecules [I58], 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 [I55]. It has been proposed that bio-photons arise as a product of redox reactions of free radicals [I1, I29]. 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 [**?**]. Destructive interference between incoming and reflected wave leaving a wave confined inside double layered structure.

5.2.2 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 [**?**] 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 [K38]. 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 [**?**] [L11]. 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 [I27] 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 [**?**]), 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 [K70] ? 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 [L16], which is also a crucial element of TGD inspired quantum biology [K77]

5.2.3 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`) [I38].

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" [I44].

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.

5.2.4 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

$$I(t) \;=\; I(0) \times exp(\lambda u) \;\; , \tag{5.2.1}$$

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

$$A_y(t) \;=\; A_0 \times u^s \;\; , \;\; s = -1/2 + iy \;\; , \;\; u = (\frac{t^2 - a_0^2}{a_0^2})^{1/2} \;\; . \tag{5.2.2}$$

The intensity would be of the form

$$I_y \;=\; \frac{A_0^2}{u} \tag{5.2.3}$$

approaching the hyperbolic form for $t >> a_0$. 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:

$$A = cos(\phi)A_{y_1} + sin(\phi)A_{y_2} \tag{5.2.4}$$

giving

$$I = \frac{1 + sin(\phi_1 + \phi_2) \times cos[(y_1 - y_2)log(u)]}{u} \tag{5.2.5}$$

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 [K84]. 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 [K84]. 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

$$A(u) = \sum_y A_y(u) \quad , \quad u = \frac{t}{t_0} \quad .$$

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.

5.3 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 [I74], the effect of hydrogen peroxide H_2O_2 on bio-photon emission from radish root cells [I73], and delayed luminescence of leaves [I75].

R. Bajpai has discussed a squeezed state description of spectral decompositions of a bio-photon signal [I76, I13]. 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.

5.3.1 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` [B5].

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.

5.3.2 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.

5.3.3 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.

5.3.4 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

$$N(t) = N(0) \times \left[1 + \frac{t}{t_0}\right]^{-k} + \frac{R}{k} \ .$$

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:

$$\frac{dN_D}{du} = -kN_D + R \ , \ dN_B = kN_D \ , \ u = log(\frac{t}{t_0} + 1) \ .$$

The rate for emission of bio-photons would be now

$$\frac{dN_B}{dt} = kN_D(0) \left[1 + \frac{t}{t_0}\right]^{-k} + R \ .$$

$k = 1$ 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`) [I22]). 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` [B5] 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?

5.4 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) [K61].

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.

5.4.1 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`) [L10]

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` [B1] 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 [**?**] 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.

5.4.2 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 [K45]. 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 [**?**, **?**, **?**]. I have discussed these findings from TGD point of view in [L11]. 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 [**?**]. 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.

5.4.3 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.

5.4.4 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 [K2]. 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 [K2, K108] or codons (this seems to be the more plausible option [L11]) 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 [I53, I59] 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 [I71, I72]: 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.

5.4.5 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 [**?**]

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 [**?**, **?**] 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 [K16] 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 [K55, K56]. 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 [K45] 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 [K114], 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 [K2] 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 [**?**] 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.

5.4.6 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.

5.5 Taos Hum As Evidence For Biophonons?

Taos hum is an experimentally well-established anomalous phenomenon which has escaped rational explanations (in the article [I49] 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.

5.5.1 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.

5.5.2 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 [I32] 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 [I17] 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 $h_{eff} = n \times h$ [K31, K32, K33, K34] 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 [I49]. 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.

5.5.3 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 [K53] 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 [K49, K53].

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 [K38] 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 [K81]. 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.

5.5.4 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 [K38] 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 [**?**]. 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 [**?**] [L11]. 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 [K55]).

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 [L11], 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 [I16].

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 [K45]. 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.

5.6 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.

5.6.1 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 [K117].

The vision of Hawkins about fundamental algorithm [L10] might find realization in TGD framework in terms of the basic anatomy of quantum jump in zero energy ontology (ZEO) [L12]. 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" [**?**, **?**]. Temporal polarization patterns are also possible and are suggested by Gariaev's group [I27].

   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.

5.6.2 Dark Photons And Biology

A lot of experimental data about the role of bio-photons in biology exist [I37, I43, I60]. Coherence [I35] and closely related delayed luminescence [I15] 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 [K49]. If one accepts dark DNA [L4, K49] 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 [K117].

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 [I27] 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 $\hbar_{eff}/\hbar$.

5.6.3 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 [K70]. 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 [**?**] 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 [**?**].

1. *In vivo* experiments of Kobayashi *et al* [**?**] 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* [**?**] 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 [**?**]. 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 [**?**]: 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 microtubules. 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 [K70].

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 [I16] would have interpretation of this pairing allowing also other than EEG frequencies as dark photon frequencies. Also the findings of Peter Gariaev [I27] suggest that also radio wave frequencies can appear as dark photon frequencies.

According to [**?**] 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 [**?**] 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 [K70, K55, K74].

- *Phosphene phenomenon: a new concept* [**?**].

  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* [**?**].

  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 [**?**]. 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 [**?**]. 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* [**?**].

  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 [**?**].

  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* [**?**].

  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* [**?**].

  The motivation of the article is the experimental proof of the existence of spontaneous ultraweak photon emission and visible light induced delayed ultraweak photon emission from in vitro freshly isolated rat's whole eye, lens, vitreous humor and retina [**?**]. 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 [**?**] 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 [I41](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) [L11, K13]. 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 [K31, K32, K33, K34]. 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 biophoton 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?

5.6.4 Dark Photons, Meditative States, And Qigong Practices

Various experiments demonstrate that meditation tends to reduce bio-photon emission [**?**, **?**]. 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 [**?**], the effects of mental concentration on bio-photon emission [**?**], temperature and bio-photon changes of the middle finger during Qigong and light imagery tasks [**?**], and comparison of bioenergy and physiological markers in qigong and acupuncture research has been carried out [**?**].

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.

5.7 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 [**?**, **?**, **?**] 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).

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Chapter 6

Comments about the recent experiments by the group of Michael Persinger

6.1 Introduction

Michael Persinger's group reports (see `http://tinyurl.com/ycv7876g`) [?, ?, ?] three very interesting experimental discoveries relating to EEG, magnetic fields, photon emissions from brain, and macroscopic quantum coherence.

In the first article (see `http://tinyurl.com/y7nbr496`) [?] entitled *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* correlations between cerebral photons emissions, EEG, and changes of the proximal geomagnetic field are reported. The findings provide support for the proposal of Hu and Wu [?] that nerve pulse activity could induce spin flips of spin networks assignable to cell membrane motivated by the observation that the magnetic spin-spin interaction between protons at a distance of 10 nm (cell membrane thickness) corresponds to energies for which frequency is in EEG range.

In the second article (see `http://tinyurl.com/ycv53lye`) [?] entitled *Demonstration of Entanglement of "Pure" Photon Emissions at Two Locations That Share Specific Configurations of Magnetic Fields: Implications for Translocation of Consciousness* the group reports an excess correlation between "pure" photon emissions at two locations separated by few meters that share specific correlations of frequency modulated magnetic fields. The photon emissions were from LEDs in the experiment consider. In an earlier similar experiment, which is also discussed, they were from chemical reactions occurring in solutions contained by cell cultures.

In the third article (see `http://tinyurl.com/ya4yb6bc`) [?] entitled *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* an excess correlation of brain activity of subject persons separated by 300 km and sharing the same circular rotating, angular accelerating magnetic fields is reported.

It turns out that the experiments provide support for several TGD inspired ideas about living matter: magnetic flux quanta as generators of macroscopic quantum entanglement, dark matter as a hierarchy of macroscopic quantum phases with large effective Planck constant, DNA-cell membrane system as a topological quantum computer with nucleotides and lipids connected by magnetic flux tubes with ends assignable to phosphate containing molecules, and the proposal that "dark" nuclei consisting of dark proton strings could provide a representation of the genetic code. The proposal of Hu and Wu [?] translates into the assumption that lipids of the two layers of the cell membrane are accompanied by dark protons which arrange themselves as dark protonic strings defining representation for DNA sequences.

In the sequel I briefly explain my own interpretation of these experiments and their outcomes from TGD point of view and show that a nice interpretation of the findings emerges. Before going

into this it is however appropriate to summarize briefly those aspects of TGD-based view about living matter which are relevant for the interpretation of the experiments.

6.1.1 Key Aspects Of The TGD-Inspired Vision About Living Matter

The following are the key ingredients of TGD-inspired vision about living matter needed for our argument:

1. The notion of many-sheeted space-time is the first new element [**?**, K44]. Space-times are 4-D surfaces in 8-D space-time $M^4 \times CP_2$ so that one has what might be called sub-manifold gravity. Any physical system corresponds to a space-time sheet characterizing its shape and size. The outer boundaries of macroscopic objects correspond to causal boundaries at which the signature of the induced metric of the space-time surface changes. Therefore space-time surfaces are topologically non-trivial in all scales and we directly perceive it. Space-time surfaces form a fractal hierarchy in the sense that subsystems of a system correspond to space-time sheets topologically condensed on it via the formation of wormhole contacts which are regions of space-time with an Euclidian signature of the induced metric.

   Also the notion of classical field is topologized. Various classical fields are subject to what might be called topological field quantization. For instance, radiation fields decompose to topological light rays and magnetic field to magnetic flux quanta (flux tubes and flux sheets). Topological field quantization is of special importance in living matter and leads to the notion of field body and magnetic body as additional structural and functional parts of a living system.

2. p-Adic physics [K98] defines a further basic element. p-Adic number fields are proposed to serve as correlates for cognition in the sense that one can speak about p-adic space-time sheets as correlates for cognition and for intentions [K67, K113] The quantum jump transforming p-adic space-time sheet to a real one corresponds to a transformation of intention to action. The generation of though in turn corresponds to an opposite of this transition. Zero energy ontology makes this picture internally consistent and no breaking of conservation laws is implied.

   p-Adic length scale hypothesis [K68] states that p-adic primes near powers of 2 are of special physical significance and Mersenne primes $M_n = 2^n - 1$ especially so. A possible explanation for the importance of these primes is that evolution corresponds to a gradually increasing complexity. The primes slightly below power of two are simple in the sense that all digits in their pinary expansion are "1":s expect possibly for some of the first ones, and are physically especially interesting because they should have emerged first if the number theoretical evolution proceeds from simple to more complex. Mersenne primes have only "1":s in their pinary expansion so that they are the simplest possible primes and indeed seem to correspond to fundamental physical scales. This leads to quite powerful predictions in particle physics context.

   In the scales of living matter a number theoretical miracle occurs: the length scale range from 10 nm (cell membrane thickness to 2.5 μm (size scale of cell nucleus) contains as many as four electron Compton scales $L_e(k) = \sqrt{5}L(k)$ defined by Gaussian Mersennes $M_{G,n} = (1+i)^n - 1$: obviously they correspond to p-adic primes near p^k, $k = 151, 157, 163, 167$.

3. The hierarchy of *effective* Planck constants [K40] coming as integer multiples $\hbar_{eff} = n\hbar$ of the ordinary Planck constant was partially motivated by the findings of Blackman [**?**] and others related to the unexpected effects of ELF em fields on vertebrate brain. These effects look quantal but this should not be possible since the cyclotron energies in the magnetic field $.2 \times 10^{-4}$ T (2/5 times the nominal value of the Earth's magnetic field $B_E = .5 \times 10^{-4}$ T) are 10 orders of magnitude below the thermal threshold.

   This led to the hypothesis about the value spectrum of Planck constants. The phases of ordinary matter with non-standard value of effective Planck constant are identified as dark matter. Later two different - possibly equivalent - reductions of the hierarchy to that for *effective* values of $\hbar$ have emerged in TGD framework [K113].

One of the most speculative ideas related to the dark matter hierarchy is based on the observation that a simple model for dark proton implies that the states of dark proton are in 1-1 correspondence with DNA, RNA, tRNA, and amino-acids, and that there is a simple rule reproducing vertebrate genetic code [L4, K49]. Dark nuclei defined by sequences of dark protons would define the analogs of DNA sequences so that genetic code would not be a outcome of random bio-chemical selection but a basic element of particle physics, and biological systems would only define a secondary representation of the fundamental genetic code. This proposal has far reaching implications. Surprisingly, the findings of the first article [**?**] supporting the hypothesis of Hu and Wu [**?**] about proton spin networks combined with the dark DNA hypothesis lead to a concrete model for the proton spin networks as paired dark DNA sequences assignable to the two lipid layers of the cell membrane.

4. Magnetic flux tubes carrying dark matter take central role in TGD inspired quantum biology. The knotting and braiding of the flux tubes makes possible topological quantum computation and leads to the hypothesis that DNA and cell membrane connected by flux tubes form a topological quantum computer [K2]. Flux tubes can connect sub-systems of living organisms or even different organisms to form coherent structural and functional units. Indeed, the large value of $\hbar_{eff}$ makes possible macroscopic quantum coherence. In particular, biomolecules can be connected by flux tubes to coherent structures. The reconnection of flux tubes plays a key role in the proposed model bio-chemical reactions and bio-catalysis. Important are also the phase transitions changing the value of Planck constant inducing in turn a change of the length of the flux tube identified as a quantal length scale depending of $\hbar_{eff}$. These phase transitions could be responsible for the phase transitions changing dramatically the density of matter in cellular interior (say sol-gel transition).

   Cyclotron Bose-Einstein condensates at magnetic flux tubes are proposed to be a characteristic of living systems [K11]. Cyclotron frequencies are classical (no dependence on Planck constant) but cyclotron energies scale like $\hbar_{eff}$ so that for a large enough value of the effective Planck constant cyclotron energies of dark photons are above thermal threshold, and can induce macroscopic quantum coherence. Dark photons decay to bunches of ordinary photons and an attractive hypothesis is that bio-photons result as decay products of dark photons.

   The notion of magnetic body emerges naturally. Any physical system is accompanied by magnetic fields which in TGD Universe defines separate entity, which can be called magnetic body. Magnetic body is identified as an intentional agent using biological body as sensory receptor and motor instrument. Magnetic body has an onion like structure corresponding to the hierarchy of space-time sheets defining physical system, say biological body. The size of the magnetic body is much larger than that of biological body. 10 Hz frequency corresponds to a layer with size large than the size scale of Earth.

5. Zero energy ontology (ZEO) [K7] is a further basic element. In zero energy ontology physical states are zero energy states consisting of pairs of positive and negative energy states having opposite net quantum numbers and being localized to the opposite light-like boundaries of $CD \times CP_2$, where CD is the causal diamond identified as an intersection of future and past directed light-cones and defining a structure analogous to a double pyramid (a convenient shorthand for $CD \times CP_2$ is simply CD).

   The interpretation of zero energy states is as counterparts of pairs of initial and final states of physical events in positive energy ontology. CDs form a fractal hierarchy with CDs within CDs. The size scales of CDs come as integer multiples of CP_2 size scale about 10^4 Planck lengths. One can interpret CD as an embedding space correlate for a "spotlight of consciousness" in the sense that the conscious experience of self associated with a given CD is about the region defined by CD. Space-time sheets within CD serve as correlates for selves at space-time level.

   Also elementary particles are expected to be accompanied by CDs, and one especially important prediction is that the time scale of the CD associated with electron is .1 seconds, which corresponds to the fundamental 10 Hz bio-rhythm. All elementary particles correspond to macroscopic time scales and u and d quarks would correspond to time scales between 1 ms and .1 seconds.

6.1.2 Cell Membrane As Super-Conductor And A Model For Eeg

The proposal is that the cell membrane is accompanied by super-conducting dark magnetic flux tubes [K79]. Cooper pairs of electrons, protons, and biologically important fermionic ions would be the carriers of supra currents besides bosonic ions such as Ca^{++} and Mg^{++}. Note that the new exotic nuclear physics suggested by TGD allows to imagine that fermionic nuclei could appear as bosonic variants with essentially the same chemical properties [L4].

Josephson currents through cell membrane have frequency $f = eV/\hbar_{eff}$ so that in this case the energy $E = eV$ identifiable as the energy of electron or proton gained in traversing the cell membrane is a classical quantity whereas Josephson frequency is quantal [K79]. The situation is opposite to this for cyclotron frequencies and energies. Obviously, large values of $\hbar_{eff}$ correspond to low Josephson frequencies. Soliton sequencies associated with the Sine-Gordon equation governing the dynamics for small variations of membrane potential would represent ground states of axonal membranes mathematically, analogous to sequences of mathematical penduli rotating in phase. Nerve pulse generation would mean a perturbation in which one pendulum is kicked [K79].

There are two alternative models for the cell membrane as a Josephson junction [K11].

1. For the conservative option [K11] the cell membrane is a far-from-vacuum extremal and various charged particles experience only the electromagnetic field. The energy scale of excitations is determined by the electric voltage and is given by $E = eV$. Nerve pulse generation would be associated with this kind of membranes. Josephson radiation with harmonics of $f = eV/\hbar_{eff}$ is one signature of super-conductivity.

   One also ends up with an explanation of EEG in this framework [K38]. The function of EEG would be communication of sensory data from cell membrane to the magnetic body and control of biological body via flux sheets traversing through DNA, where genetic expression is activated by the control signals. EEG frequencies are linear combinations of harmonics of Josephson frequencies and of the increments of cyclotron frequencies. Cyclotron transitions can be also accompanied by a spin flip. This model allows one to identify EEG bands. The hierarchy of Planck constants suggest a generalization of EEG and its variants (say EKG) to a fractal hierarchy obtained by scaling EEG. For large enough values of $\hbar$ cyclotron contributions to EEG energies would correspond to energies above thermal threshold as also Josephson frequency (Josephson energy $E = eV_{thr}$, where V_{thr} is the value of resting potential at which nerve pulse is generated is just at the thermal threshold). This would make possible the correlation of EEG with the brain state and also quantum biocontrol by using photons with EEG frequencies.

2. For the non-conservative option [K37] cell membrane is near-to vacuum extremal. The classical Z^0 fields predicted by TGD dominate over em fields, and the voltage must be replaced by a combination of Z^0 and em voltages. By assuming that the Weinberg angle is considerably smaller in this phase than in the standard phase the energies gained by various ions correspond to visible photons. This hypothesis allows one to understand the frequencies for which photoreceptors - which do not directly generate nerve pulses - are most sensitive. Near-vacuum extremal property obviously implies high sensitivity to perturbations making the sensory receptor optimal.

An interesting possibility is that the far-from-, respectively near-to-vacuum extremal options are realized for the neurons of left *resp.* right hemisphere. This option finds support from the observation of Persinger *et al* [**?**] that visible photon emissions are mostly from the right hemisphere. Another possibility is that glial cells as cells which do not generate nerve pulses correspond to near-to vacuum extremals. The identifications do not exclude each other.

6.1.3 Learning To Apply The Notion Of Induced Field

The geometrization of classical gauge fields and gravitational fields relying on the induction of spinor connection of CP_2 and $M^4 \times CP_2$ metric to the space-time surface is one of the key ideas of TGD and it is useful to get more concrete understanding of the induced fields since this notion will be applied in the sequel.

The basic objection and its resolution

The basic objection against the induced fields is that they reduce the dynamics to that of only 4 field like variables since the 8 embedding space coordinates take the role of field variables and 4 of them are eliminated by general coordinate invariance as field variables. Besides this preferred extremals of Kähler action represent space-time surfaces carrying very restricted kind of patterns of induced gauge fields analogous to Bohr orbits.

Many-sheeted space-time however saves the situation. Each system creates its own field body represented in terms of topological field quanta. If these field bodies have common M^4 projection, a test particle topologically condenses to each of these field body (touches each of them), and the effects of these fields sum up although fields do not interfere as they would do in ordinary field theory.

How could one generate dark photons with large $\hbar$?

The observation which led to the proposal of the effective hierarchy of Planck constants, was that microwaves with frequency of f_h modulated by ELF frequency f_l induce in vertebrate brain effects which could be understood in terms of cyclotron frequencies assignable to quantal cyclotron transitions in an endogenous magnetic field $B_{end} = .2$ Gauss for which cyclotron frequency was equal to ELF frequency: $f_c = f_l$. These effects are possible only if the cyclotron energy is above thermal energy, and this led to the proposal about the hierarchy of Planck constants.

The key question is how the modulation by ELF frequency could generate dark photons with large $\hbar_{eff}$. A possible answer to this question comes from another question. Topological field quantization forces one to ask what is exactly implied by the amplitude modulation of fields.

The simplest modulation corresponds to a multiplication of rapidly oscillating field with a slowly varying oscillating amplitude so that amplitudes with frequencies $f_h \pm f_l$ result ("h" and "l" refer to "high" and "low"). The natural thing to do is to develop the two amplitudes with frequencies $f_h \pm f_l$ in Fourier series in time interval $T = 1/f_l$. All harmonics of f_l appear and coefficients of the expansion are proportional to $1/(f_h - (n \pm 1)f_l)$. Maximal amplitudes correspond to $f_h \simeq (n \pm 1)f_l$. This suggests that when this almost-resonant condition is satisfied the generation of dark photons with frequency f_l and energy $\hbar_{eff} f_l$, with $\hbar_{eff} \simeq f_h/f_l$, can take place at a considerable rate. If this argument is correct, one could generate dark photons with given $\hbar_{eff}$ by using modulation satisfying the condition $f_h/f_l = \hbar_{eff}$.

In the case of ELF em fields interacting with brain this is not enough since microwave photons have energies below the thermal threshold E_{th}. Bio-systems however contain photons with energy above thermal threshold - say bio-photons with frequencies f in visible range or infrared Josephson photons generated by cell membrane Josephson currents; the fields associated with MEs ("massless extremals", topological light rays) accompanying these many-photon states can be modulated by the ELF modulated microwaves. Since one can say that a modulation of modulation is also a modulation, the outcome is modulation (f, f_{ELF}) producing dark photons with $\hbar_{eff} \simeq f/f_{ELF}$ with energies about E_{th}.

This mechanism would explain the "scaling law of homeopathy"" [K49] stating that fields with low frequencies f_l are somehow transformed to fields with high frequencies f_h and vice versa. The proposal has been that large $\hbar_{eff}$ photons with $\hbar_{eff} \simeq f_h/f_l$ decay to ordinary photons or vice versa. This transformation has quite concrete description: $\hbar_{eff} = n$ photons correspond to n-furcations of space-time surface made possible by the non-determinism of Kähler action. All n-sheets of the n-furcation would be present and each of them would carry photon with frequency f_l and total energy would be $\hbar_{eff} f_l = f_h$.

How to describe time-varying magnetic fields?

The topological flux quantization for static magnetic fields is easy to understand. The description of time varying magnetic fields in terms of flux quanta is however a non-trivial exercise in thinking in terms of topological field quanta.

Flux quantization implies that the magnetic dipole field decomposes into closed flux tubes with a straight part inside dipole and a portion outside the dipole carrying return flux in roughly opposite direction also arranged to flux tubes.

The basic assumption is that the flux tube structure of dipole field is not lost but is only re-arranged as the dipole field oscillates. As the dipole strength decreases the flux tubes along field lines outside the dipole contract so that eventually the closed flux tubes of dipole field degenerate to those of wormhole magnetic fields [K114] restricted inside the dipole and consisting of parallel flux tube space-time sheets with same M^4 projection and carrying opposite magnetic field strength and having distance of order CP_2 length along CP_2 direction. A charged particle topologically condensing at both sheets experiences the sum of the magnetic fields, which vanishes. As the sign of dipole changes, the flux tubes in the interior of dipole begin to move to the exterior of the dipole. In operational sense this dynamics is approximated well by Maxwell's theory or vice versa.

How are the electric electric fields associated with the time-varying magnetic fields predicted by Faraday law represented? These fields are rotational with flux lines rotating around the magnetic field. In Maxwell's theory one would have single vortex like structure. In TGD this vortex-like structure decomposes into smaller vortices assignable to individual flux tubes just like the rotational flow of super-fluid decomposes into smaller vortices satisfying quantization condition analogous to the quantization of the magnetic flux.

Also the geometro-dynamics for the flux quanta of electric field is possible and in this case magnetic fields induced by time dependent electric fields are assignable to flux quanta. Cell membrane is a good example of this kind of situation. Quite generally, the geometro-dynamics of topological field quanta together with the possibility to have varying overlapping M^4 projections allows to reproduce the smooth dynamics of Maxwell fields.

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` [L14].

6.2 First Article

The first article has the title *Congruence of Energies for Cerebral Photon Emissions, Quantitative EEG Activities and $\sim$ 5 nT Changes in the Proximal Geomagnetic Field Support Spin-based Hypothesis of Consciousness*, which already summarizes the findings.

6.2.1 Findings

In the article (see `http://tinyurl.com/y7nbr496`) [?] Persinger's group reports simultaneous changes in photon emissions, EEG activity, and alterations of proximal geomagnetic field when a person sitting in dark is imagining white light or not.

According to the article's abstract,

> the hypothesis by Hu & Wu that networks of nuclear spins in neural membranes could be modulated by action potentials was explored by measurements of the quantitative changes in photon emissions, electroencephalographic activity, and alterations in the proximal geomagnetic field during successive periods when a subject sitting in the dark imagined white light or did not. During brief periods of imagining white light the power density of photon emissions from the right hemisphere was about 10^{-11} Wm^{-2} that was congruent with magnetic energy within the volume associated with a diminishment of $\sim$ 7 nT as predicted by the dipole-dipole coupling relation across the neuronal cell membrane. Spectral analyses showed maxima in power from electroencephalographic activity within the parahippocampal region and photon emissions from the right hemisphere with shared phase modulations equivalent to about 20 ms. Beat frequencies (6 Hz) between peak power in photon (17 Hz) and brain (11 Hz) amplitude fluctuations during imagining light were equivalent to energy differences within the visible wavelength that were identical to the intrinsic 8 Hz rhythmic variations of neurons within the parahippocampal gyrus. Several quantitative solutions strongly suggested that spin energies can accommodate the interactions between protons, electrons, and photons and the action potentials associated with intention, consciousness, and entanglement.

The authors interpret the results in terms of entanglement identified as enhanced correlations. Entanglement in this sense does not correspond to quantum entanglement. To my opinion

(quantum) coherence would be a more standard manner to interpret the findings. Quantum coherence of course also makes possible quantum entanglement.

Spin flips, whose importance for consciousness has been emphasized by Hu and Wu [**?**], would occur between spin triplet and singlet states of pairs of protons belonging to the spin network. The basic finding is that the energy changes are accompanied by changes in EEG power.

Note that spin flips are possible also for cyclotron states proposed to be important for consciousness in TGD approach. In the case of electron the change of the energy in spin flip is in excellent approximation the same as in the transition $n \to n \pm 1$ of cyclotron state characterized by integer n (radial wave functions of electron in constant magnetic field correspond to those of harmonic oscillator). For ions the Lande factor g characterizes the effective nuclear angular momentum and appears in the spin flip energy and also now the frequencies involved are in EEG range.

The correlation of photon emissions with imagination of white light supports the hypothesis that EEG photons are responsible for communications to and control of biological body by magnetic body.

6.2.2 TGD Inspired Interpretation Of The Findings

What has been observed is correlation between EEG, emission of visible photons, and weakening of Earth's magnetic field with the change of magnetic energy equal to the energy of radiated photons. There is also evidence that spin flip transitions for protons are involved.

What is the origin of the visible photons?

The basic question concerns the origin of the visible photons.

1. An attractive general hypothesis is that the visible photons result in the transformation of dark EEG photons to ordinary visible photons. In TGD based model EEG (and its predicted fractal variants) correspond to dark photons with large *effective* value of $\hbar$ - call it $\hbar_{eff}$ - and energy $E = h_{eff}f$ in infrared or visible range and perhaps even in UV. Also bio-photons would result from these large $\hbar$ "dark" photons as they decay to bunches of ordinary photons. The wavelengths of dark photons with given energy are scaled by $\hbar_{eff}/\hbar$ predicted to be integer. The transformation of EEG photons to ordinary visible photons could explain the correlation between EEG and visible photon emission reported by Persinger's group. This kind of process would generate also bio-photons.

2. The mechanism providing energy for dark photons (in particular EEG photons) would provide it also for the visible photons. According to the authors, the energy would come from the Earth's magnetic field which I as inhabitant of many-sheeted space-time take liberty to translate to "measured magnetic field". What is interesting is that magnetic body would serve as a provided of metabolic energy. It is interesting to notice that in TGD based cosmology matter is created from the dark energy identified as Kähler magnetic energy assignable to magnetic flux tubes.

3. Authors conclude that the energy liberated per action potential is $E = eV_{rest}$. In TGD framework it could correspond to either a photon of Josephson radiation or the energy liberated when an electron traverses the cell membrane. What is troublesome is that this energy corresponds to IR photon just above thermal threshold rather than visible photon. The non-conservative model for the cell membrane mentioned above (applying to photo-receptor cells at least) could explain why visible photons rather than infrared photons with energy $E = eV_{rest}$ correspond to photons of the Josephson radiation.

4. The model based on the observation of Hu and Wu [**?**] suggesting that action potentials affect a spin network of protons (possibly at opposite ends of lipid of two lipid layers making cell membrane) looks like a totally different explanation from what would come first in mind in TGD framework. Could the spin network proposal of Hu and Wu be integrated to the picture of living matter provided by TGD? This is the question to be considered next.

The spin network hypothesis of Hu and Wu from TGD point of view

The hypothesis of Hu and Wu (see `http://tinyurl.com/yb5emq27`) [?] states that nuclear spin networks of nuclei associated with the cell membrane are relevant for consciousness in the sense that action potential induces modulations of the coupling parameters describing the magnetic interaction between neighboring spins of the spin network.

1. A direct calculation using the value of proton magnetic moment gives that the magnetic field created by proton at distance defined by cell membrane thickness of 10 nm is 3 nT. There are also other factors involved, and the estimate of Hu is that the field is about 5 nT.

2. The crucial observation is that the classical spin-spin interaction energy for two protons at distance $d = 10$ nm defined by cell membrane thickness and given by $E_{s-s} = -\mu \cdot B$, where B is the dipole field created by proton, corresponds to a frequency of the order 10^{-14} eV and thus is in EEG range. This can be seen by a direct calculation by assuming that proton creates a dipole field with Lande factor of proton.

   The frequencies assignable to the energies of neighboring interacting proton spins at distance d are in EEG range also when the effects of the environment are taken into account. For instance, the Hamiltonian for a rotationally symmetric nearest neighbor spin-spin interaction characterized in terms of so called J-factor, predicts in the case of protons frequency differences ΔE between singlet and triplet states varying in the range 5-25 Hz.

   For heavier nuclei these interaction energies scale down like $1/A^2$, A the mass number, so that a naïve conclusion would be that the frequencies tend to be below 5 Hz scale. Proton would therefore be in a completely unique position. That EEG frequencies result in case of proton suggest that cell membrane thickness is not 10 nm by a pure accident (not that p-adic length scale hypothesis fixes assigns it to the p-adic length scale $L(k = 151)$, where $k = 151$ characterize Gaussian Mersenne prime.

The fact that the frequencies for energy differences of singlets and triplets are in EEG range is highly relevant also from TGD point view since this energy range makes it possible for EEG frequencies to induce spin flips.

1. In TGD framework fermionic spin and fermion numbers in various modes of second quantized induced spinor field (1 or 0) are predicted to serve as correlates for Boolean cognition (see `http://tinyurl.com/y73smj9v`) [K25] so that there are good reasons to expect that also spin flips are important. One might even think that protonic and even nuclear spins could be utilized to build Boolean representations.

2. The basic objection against the proposal of Hu and Wu is same as that against the findings of Blackman and others: quantum coherence is not possible since the energy differences corresponding to (say) frequency of 5 Hz is about 12 orders of magnitude below thermal threshold. Trom the basic relation $E = h_{eff} f$ it is clear that the objection can be circumvented for large values of effective Planck constant, which can take raise the energies involved to those of IR or perhaps even visible photons.

3. Authors conclude that the energy emitted per single action potential is $E = eV_{rest}$ which corresponds to IR photon just at the thermal threshold. It is however visible photons which are emitted. Why not photons with the Josephson energy $E = eV_{rest}$ just at the thermal threshold?

   If the photons would result when electron or proton traverses cell membrane and liberates potential energy as a photon or if the emitted IR photon could be interpreted as a photon of Josephson radiation this would be the case. TGD allows also to imagine that the cell membranes in question correspond to the non-conservative option for the model of cell membrane as Josephson junction for which V_{rest} contains Z^0 potential as a dominating contribution and gives rise to Josephson photons with energies in visible range.

   If one takes the proposal of Hu and Wu seriously, the visible photons would have different origin, and one must perhaps give up the assumption that the estimate of authors forces the identification of basic energy quantum emitted in the process considered as $E = eV_{rest}$.

Authors state that the energy associated with visible photon emission should be equivalent to the energy emitted in the emission of photons. What can one conclude from this?

1. An attractive possibility would be "dark" spin network formed by spin-coupled protons, whose members are associated with the lipids of the two lipid layers with lipids. The number of the lipids per cell membrane would be roughly $N_l = r^2/d^2$, with lipids thickness estimated to be $d \sim .1$ nm. For $r \sim 10^{-4}$ m corresponding to a relatively large neuron this would give $N_l = 10^{14}$.

   This number would give also the maximum number of spin pairs participating in phase transition and an estimate for the value of $\hbar_{eff}$ from $N_l \Delta E_{s-s} = E_{ph}$ as

   $$N_l = \frac{E_{ph}}{E_{s-s}} = \frac{f_{ph}}{f_{s-s}} \quad .$$

   Suppose that all dipoles make a simultaneous spin flip with energy change $\Delta E = hf$, $f_{s-s} = 5$ Hz generating an energy of $E_{ph} = 1eV$ corresponding to a frequency of 2.4×10^{14} Hz. This requires $N_l \sim .5 \times 10^{14}$. It is encouraging that the rough estimates are consistent with each other.

2. That all protonic spin pairs make a simultaneous spin flip between singlet and triplet states of neighboring pairs looks like a phase transition. This suggests strongly macroscopic quantum coherence. What looks extremely strange is that a single visible photon should be emitted in the process since the entire magnetized region would behave like single spin! In standard physics this is not possible. TGD however leads to a possible realization of this kind of process as a mechanism of psychokinesis (see `http://tinyurl.com/yckq32pv`) [L9].

   The hierarchy of effective Planck constants could resolve the paradox. If one has $\hbar_{eff}/\hbar \simeq E_{ph}/\Delta E \simeq .5 \times 10^{14}$, the emitted photon would be large $\hbar$ dark photon with frequency 5 Hz and the energy of visible photon and geometrically would corresponds to a n-furcation of space-time with $n = \hbar_{eff}/\hbar$ sheets each carrying single 5 Hz photon. Each dipole pair emits ELF photon but they combine to single dark ELF photon with the energy of single photon.

It seems that it is not natural to assign the photon emission to cyclotron transitions ionic cyclotron B-E condensates or to the transitions associated with the cell membrane Josephson junctions. Also the model based on the observation of Hu and Wu is very attractive. This does not add a completely new element to TGD. One can find a nice connection with one of the TGD inspired basic ideas about genetic code, namely the dark realization of genetic code as sequences of dark protons.

1. About 7 years ago I constructed a model for dark nuclei identifying them as strings of dark nucleons [L4, K49]. The model of dark nucleon yielded a compete surprise: the states of the nucleon were in 1-1 correspondence with DNA, RNA, tRNA, and amino-acids and vertebrate genetic code could be understood in a simple manner. This led to the vision that dark proton sequences allow a virtual world realization of genetic code making possible a kind of R&D department developing and testing various genetic alternatives. The genetic discoveries are however useful only if they can be used. This requires a generalization of transcription process allowing to transcribe DNA and RNA and perhaps even tRNA, and amino-acids to their dark counterparts and vice versa. This requires that dark nucleon sequences have same size scale as ordinary DNA, RNA, and amino-acids and that they could accompany the biomolecules.

   This fixes the size scale of dark proton to be of the order of the volume defined by the length L corresponding to single nucleotide in nucleotide sequence. The value of Planck constant would be of the order $\hbar_{eff}/\hbar \sim L/r_p \simeq 2.3 \times 10^5$, $r_p = \hbar/m_p \simeq 1.3 \times 10^{-15}$ m and$L \simeq .3$ nm.

2. At the same time I also constructed a model of DNA and cell membrane acting as a topological quantum computer [K2]. DNA nucleotides would be connected to lipids of the inner lipid layer of the cell membrane by magnetic flux tubes, whose braiding would define the topological quantum computer programs. The braids would continue from the outer lipid layers to

the membranes of other cells and in this manner bind the cells to a kind of network. The strands could have at their ends molecules containing phosphates to make possible transfer of metabolic energy to the system.

3. Dark protons could be generated in the ionization of OH group to OH^- as proton drops to dark space-time sheet and possibly becomes a part of dark proton sequences.

   (a) The basic process would be formation of dark water in this manner and the rich spectrum of anomalies of water could be understood in terms of temperature dependence fraction of dark protons [K37].

   (b) OH groups are also associated with the hydrophilic ends of lipids such as fatty acids (see `http://tinyurl.com/cqq2nd9`), glycerolipids, and phospholipids, which are the basic structural element of cell membranes. In phospholipids OH is associated with phosphate. In the DNA strand the phosphates contain O^- identifiable as OH^- resulting when proton of H drops to dark space-time sheet and possibly becomes part of dark proton sequence.

   (c) Also carbohydrates, in particular sugars, which are basic building brick of metabolism and defined the sugar backbone of DNA and RNA, contain a large number of OH groups. The model of DNA as topological quantum computer led to a proposal that magnetic flux tubes have OH or OH^- groups as their ends. These observations would allow magnetic flux tubes have dark protons at either or both ends. According to the earlier proposal [K2] magnetic flux tubes to have OH and $O =$ at their ends. Earlier picture need not to be modified if the cell membrane carries dark double DNA strand connected to the ordinary DNA double strand inside nucleus. Similar connections would be natural also between DNA and amino-acids and their dark counterparts possibly associated with the cell membrane and reconnection of the color magnetic flux tubes could allow to build and manipulate these connections.

4. This would predict that single DNA codon, which corresponds to a length of.33 nm along DNA strand is connected to single lipid by magnetic flux tube or three color magnetic flux tubes to corresponding proton consisting of 3 quarks. This seems to be consistent with the width of single lipid in lipid bilayer if one takes seriously the illustration of the Wikipedia article (see `http://tinyurl.com/yahmx3s7`). Note that in the earlier model single nucleotide was assumed to be connected by a magnetic flux tube to *single lipid*.

5. A further natural working hypothesis is that the proton pairs assignable to the OH^- groups at the hydrophilic ends of opposite lipid layers can also be connected by triplets of (color) magnetic flux tubes giving rise to the dipole-dipole interaction. This connection need not be permanent and could disappear or appear by the reconnection of the magnetic flux tubes. This could correspond to the transiotion to singlet state for proton pairs and would require energy. The working hypothesis of [K2] indeed is that during topological quantum computation the connection is split so that the cell is isolated from external world. The connection would be restored as the computation halts. Photon emission would therefore be seen as a signature of topological quantum computation.

The fact that the proton cyclotron frequency 300 Hz in $B_{end} = .2$ Gauss is the only cyclotron frequency above EEG range, one can ask whether biologically important dark ions form cyclotron Bose-Einstein condensates (possibly also Cooper pairs if fermions), dark protons form a cell membrane spin network, and dark electrons arrange to dark Cooper pairs making cell membrane a super-conductor. This would provide a unified picture about the role of various particle in TGD inspired vision about living matter.

Correlation of photon emissions with the weakening of the Earth's magnetic field

Authors say *During brief periods of imagining white light the power density of photon emissions from the right hemisphere was about* 10^{-11} Wm^{-2} *that was congruent with magnetic energy within*

the volume associated with a diminishment of $\sim$ *7 nT as predicted by the dipole-dipole coupling relation across the neuronal cell membrane.*

The experiment is to some extent a replication of earlier experiment of [**?**] in which it was observed that visible photon emissions mainly from the right hemisphere is accompanied by a weakening of the horizontal component of the Earth's magnetic field. Decreases over 10 to 15 s of 15 nT and 5 nT at 0.25 m and 1 m from the right side of the head of the subject person were associated with the same magnitude of energy (10^{-11} J) that was associated with the net increase in photon emissions during that period. This energy - assuming each action potential is associated with energy of $eV_{rest} = 1.9 \times 10^{-20}$ J - would be the equivalent of the activity of about 1 billion neurons.

1. If I have understood correctly, the weakening of the magnetic field outside the head of the subject person would be due to magnetic energy change associated with the spin flips taking place in the cell membrane and absorbing the needed energy from this magnetic field. This would obviously represent a new kind of metabolic activity: magnetic field would provide the needed metabolic energy instead of ATP-ADP process. That magnetic body could directly use its magnetic energy to control biological processes, would mean quite a dramatic modification of the usual view about metabolism.

2. The nuclear magnetization disappears for a moment in a transition from spin triplet to spin singlet state, which then spontaneously decay to triplet state again. The excitation of singlet state requires energy so that the magnetic field outside should weaken if it pays the energy bill. The contribution of magnetic dipoles to the horizontal magnetic field component measured outside the head of the subject person disappears and if the direction of dipole magnetization correlates with the direction of the magnetic field the strength of the magnetic field is reduced. The correlation would guarantee that the magnetic fields from different pairs of dipoles do not interfere to zero. Some kind of ordering of the orientations of neurons perhaps induced by the layered structure of cortex and of the almost collinearity of the myelinated axons of white matter is required.

3. Spin-flip transition from triplet to singlet state would change the contribution of magnetic dipoles to the net magnetic field and thus affect the net magnetic field experienced by a test particle. Could this explain the reduction of B_E by factor about 1.8×10^{-4}? At distance of order.1 meter the dipole field created by proton is very small: by a factor 10^{-21} weaker than the 9 nT field created at distance of $d = 10$ nm. The fields of neurons each containing a contribution of about 10^{14} protons sum up and the estimate is that there are 10^9 active neurons. The resulting net factor of 10^{23} could make possible reduction by 9 nT.

4. Triplet-to-singlet spin flip transition taking its energy from the magnetic field is the interpretation suggested by the experiments. The return to the ground state would liberate this energy as large $\hbar_{eff}$ quanta with energies of visible photons transforming later to ordinary visible photons. Therefore the radiated energy could indeed be magnetic energy also in TGD. Of course, also metabolism might drive particles directly to the excited cyclotron states and is expected provide the energy needed to regenerate the magnetic fields since the energy of visible photons is lost.

5. In TGD Universe the correlation of the photon emission with changes (about 7 nT) in the measured magnetic field identified as the Earth's magnetic field B_E having nominal value of $.5 \times 10^{-4}$ T does not force to assign dark photons with the magnetic flux tubes of the Earth's magnetic field.

   (a) One can of question the assignment of 7 nT weakening to B_E as a Maxwellian description not applying in TGD framework. The changes of the horizontal component of the magnetic field are detected outside the head of the subject person is it possible to assign this change to any particular magnetic field? How to distinguish between magnetic fields associated with different space-time sheets? TGD predicts that test particles "feel" their sum if these magnetic space-time sheet have projection in the same region of Minkowski space.

The possibility to move the flux tubes in such a way that only the flux quanta of one particular component of the many-sheeted magnetic field contribute to the projection, would allow to analyze the field into these components. Note that un Maxwell's theory this is not possible. The change in the measured magnetic field could be induced by a flux tube carrying 7 nT field assignable to the proton spin network and having a projection to the same M^4 volume as a flux tube of the Earth's magnetic field or the endogenous magnetic field has. Therefore it might not be easy to distinguish between changes of B_E and B_{end}.

(b) The experimental findings of Blackman *et al* [**?**] about the effects of ELF frequencies on vertebrate brain however encourages an interpretation in terms of cyclotron frequencies for magnetic field in "dark" endogenous magnetic field $B_{end} \simeq 2B_E/5$ (this predicts that Ca^{++} cyclotron frequency is 15 Hz, which is not far from 17 Hz). It is of course possible that the flux tubes of the Earth's magnetic field thicken inside the brain so that the strength of the magnetic field is reduced accordingly.

Can one understand the ELF frequencies involved?

Authors state: *Spectral analyses showed maxima in power from electroencephalographic activity within the parahippocampal region and photon emissions from the right hemisphere with shared phase modulations equivalent to about 20 ms.*

The time scale of 20 ms appears also in the experiments of articles 2 and 3 in which rotating and frequency modulated magnetic fields where applied. This time scale corresponds to 50 Hz frequency, which has been found to have biological effects [**?**]. The cyclotron frequency of Lithium (bosonic ion) for $B_{end} = .2$ Gauss equals to 50.1 Hz (see the appendix of [K19] at `http://tinyurl.com/y75k72xe`).

Authors continue: *Beat frequencies (6 Hz) between peak power in photon (17 Hz) and brain (11 Hz) amplitude fluctuations during imagining light were equivalent to energy differences within the visible wavelength that were identical to the intrinsic 8 Hz rhythmic variations of neurons within the parahippocampal gyrus.*

Can one understand the ELF frequencies involved? In TGD framework (see `http://tinyurl.com/y96stvwg`) [K19] cyclotron states of electrons, protons, and of ions are possible [K19].

1. Ca^{++} is one important bosonic ion able to form cyclotron Bose-Einstein condensates and the 17 Hz frequency for the power of photon fluctuations could correspond to $f(Ca^{++}) = 15$ Hz: note that the strength of the endogenous magnetic field is expected to be under homeostatic control and thus vary in some range.

2. 11 Hz frequency is perhaps too far from alpha frequency 10 Hz but rather near to cyclotron frequency 11.4 Hz for Mn^{++} or 10.8 Hz of Fe^{++} in the field $B_{end} = .2$ Gauss (see the appendix of [K19] at `http://tinyurl.com/y75k72xe`).

3. The superposition of effects on test charges caused by MEs associated with 17 Hz and 11 Hz frequencies would give 6 Hz beat frequency. Note that K^+ and Cl^- (fermionic ions) have cyclotron frequencies 7.5 Hz and 8.5 Hz and their Cooper pairs might relate to parahippocampal 8 Hz frequency.

6.3 Second Article

Second article has the title *Demonstration of Entanglement of "Pure" Photon Emissions at Two Locations That Share Specific Configurations of Magnetic Fields: Implications for Translocation of Consciousness.*

In the article [**?**] (see `http://tinyurl.com/ycv53lye`) the group reports an excess correlation between "pure" photon emissions at two locations separated by few meters that share specific correlations of frequency modulated magnetic fields. The photon emissions were from chemical reactions.

According to the article's abstract,

The experimental demonstration of non-locality for photon emissions has become relevant because bio-photons are coupled to conscious activity and cognition. The experimental condition that produces doubling of photon emissions from two loci during simultaneous chemical reactions when exposed to a sequence of circular rotating magnetic fields with differential phase and group angular velocities was applied to photons from LEDs (light-emitting diodes). A significant but weaker enhancement of photon emissions as measured by photomultiplier tubes occurred when the two LEDs were activated simultaneously within two loci separated by several meters. The effect suggests that under optimal conditions photons emitted from two, magnetic field congruent, loci become macroscopically entangled and that the two loci display properties of a single space. Implications for the transposition of consciousness over large distances are considered.

What was observed was enhanced visible photon emission from LEDs subject to the same magnetic stimulation as the cell culture dishes (neurons) in the earlier experiment [**?**]. The size of the effect was however smaller. If the effect is real, the presence of organic matter (the cell culture dishes) is not absolutely necessary for the effect although it enhances it. The conclusion of the authors is that photons are carriers of consciousness. TGD inspired interpretation is that the experiment provides support for the identification of magnetic flux tubes as generators of macroscopic quantum coherence.

6.3.1 Experimental Arrangement And Results

The article describes first earlier similar experiment [**?**] using instead of LEDs chemical reactions occurring in cell culture dishes (neurons) and leading to a doubling of photon emissions serving as a signature for coherence - or entanglement as authors express it. LEDs were motivated by the hypothesis that photon field can be equated with consciousness, and to test this the cell culture dishes were replaced with LEDs. A weaker but significant enhancement of LED emissions is indeed reported.

In the following I shall consider mostly the earlier experiment (see `http://tinyurl.com/yc5wsaww`) [**?**] involving cell culture dishes which is identical to the recent one except for the mentioned replacement.

1. The distance between the cell culture dishes was a few meters as was also the distance of the solenoids from the sample located circularly around it. If I have understood correctly, the circular arrangements of solenoids were in parallel planes around the cell culture dishes (neurons) and the solenoids were directed radially to the dishes: otherwise it would not be possible to achieve a rotating magnetic field.

2. Each set of eight solenoids in circular arrangement around the cell culture dish received identical patterns of piecewise constant magnetic fields generated by potentials having 8 different values: the duration of single constant piece was 1 ms. Each solenoid created a magnetic field, whose lines emanating from the end of the solenoid were directed to the center of the cell culture dish.

3. Figure 1 of [**?**] (see `http://tinyurl.com/yc5wsaww`) describes the shapes of the AD (accelerating angular velocity, decreasing "phase" modulation) and DI (decelerating angular velocity, increasing "phase" modulation). AD configuration was represented for 8 minutes and followed by DI configuration induced the effect and it occurred immediately after the initiation of DI phase.

Consider now a more detailed description of the AD and DI phases of magnetic stimulation.

1. During AD phase the accelerated rotation of the magnetic field was achieved by creating a magnetic pulse of duration 20, 18, 16, ..., $T_n = 20 - 2n$, ... ms to subsequent solenoids so that only single solenoid contributed to the net magnetic field at any moment. This series was repeated for every rotation of 2π. During AD phase the frequency modulation was slowed down meaning the frequency decreased and also this process was same for every rotation of 2π. The optimal duration of AD phase was about 4-5 minutes.

2. During DI phase decelerated rotation was achieved by in increasing the subsequent durations by 2 ms so that a series of pulses with durations 18, 20, 22, ..., $T_n = 20 + 2n, ...$ ms was obtained. During this period frequency modulation was increased.

3. What "frequency modulation of phase" precisely means? Pictures of AD and DI temporal patterns of voltages (equivalently magnetic fields) fed to the solenoids inducing a series of values of magnetic field are given in **Fig.** 2 of [**?**] (see `http://tinyurl.com/yc5wsaww`).

   A more detailed description can be found from the earlier article by Persinger's group [**?**]. The voltage range [-5 V, 5V] was discretized to 8 pieces and the possible discretized voltages in this range are represented by 8 bits. The bit patterns were selected so that they were "physiologically patterned". The value of the magnetic field inside solenoid for n: th bit was proportional to V_n. The duration of each voltage was 1 ms - basic frequency of brain synchrony.

   During AD pattern a) with decreasing frequency and during DI pattern b) with increasing frequency was used. The numbers of points which composed each pattern were 859 (duration was 859 ms) for AD and 230 (duration of 230 ms) for DI. Only a part of the pattern could be represented since the duration of single 2π rotation was 104 ms, which corresponds to 10 Hz, a fundamental bio-rhythm (Unless there was scaling of the bit duration).

4. Within the center of the 8-solenoid configuration the value of the magnetic field averages to 1 μT. A natural assumption that this magnetic field contributes to the net effective value of the endogenous magnetic field B_{end} inducing small variations of B_{end} in turn modulating cyclotron frequencies.

   The modulated cyclotron frequency should be higher that frequency of modulation and thus higher than 1 kHz. For B_{end} this leaves only electron with cyclotron frequency $f_c = 6 \times 10^5$ Hz under consideration. The effect would be on electron Cooper pairs in the case of cell culture dishes or electrons in the case of LEDs. Electrons are indeed essential also for the function of LED.

5. The frequencies $f_n = 1/T_n$ defined by the durations of magnetic field vary during AD phase between 50 Hz and 157 Hz. During DI phase the frequencies vary between 50 Hz and 30 Hz. In [**?**] it is reported that 50 Hz frequencies have biological effects. As already noticed, 50.1 Hz corresponds to cyclotron frequency for Lithium (bosonic ion) for $B_{end} = .2$ Gauss.

6.3.2 Reconnection Of Magnetic Flux Tubes As A Mechanism Generating Macroscopic Quantum Coherence

A doubling of the rate of emissions of visible photons immediately after the AD phase in the earlier experiment [**?**] and weaker enhancement in the recent experiment using LEDs instead of cell culture disches, is interpreted as a signature of entanglement. Quantum coherence is perhaps a more appropriate manner to express the findings of the two experiments although quantum coherence makes possible also quantum entanglement. To my opinion the experiments provide support for the basic prediction of TGD inspired quantum biology that magnetic flux tubes are generators of macroscopic quantum coherence.

What seems necessary is that some flux tubes emanating from the solenoids must reconnect to form flux tubes connecting the two cell culture dishes or LEDs: reconnection is indeed one of the fundamental processes in TGD inspired theory of living matter. Without reconnection the flux tubes of the two magnetic fields remain disjoint and cannot induce macroscopic quantum coherence. The reconnection can occur only if the temporal and spatial patterns of the rotating and modulated magnetic fields are identical. These flux tube connections would induce quantum coherence by effectively binding the two systems to single system.

The doubling of the photon emission rate in the earlier experiment involving cell culture can be understood by the well-known rule that in incoherent emission the total rate is N times the individual rate, and in coherent emission N^2 times the individual rate: now N equals to 2. Also destructive interference becomes possible when the summed amplitudes are in opposite phases. This would reduce the rate below the predicted based on incoherence.

Also the enhancement of the photon emission rate from LEDs in a similar arrangement supports the view that macroscopic quantum coherence generated by the magnetic field patterns is relevant and implies that the amplitudes describing the emission of photons from the two LEDs add coherently with some probability so that constructive or possibly also destructive interference occurs. To make this statement more precise, one would need a detailed quantum model for LEDs.

6.3.3 Why AD Followed By DI Is Needed To Induce Enhanced Photon Emissions?

Why should AD period followed by DI period be most effective in inducing photon emissions? Why the flux quanta (flux tubes) do not induce any effects, when the angular velocity is constant and frequency is absent (constant magnetic field)?

1. Accelerated rotation during AD period corresponds at quantum level to an application of magnetic flux tubes from directions $\phi_n = n \times 2\pi/8$ such that the duration of the pulse is reduced in discrete steps. The process should generate frequencies coming as harmonics of $f_n = 1/T_n$. The patterns of magnetic field consisting of periods of constant magnetic field lasting 1 ms and fixed for AD and DI to be "physiologically patterned" determines the Fourier decomposition. The duration of 1 ms brings in harmonics of kHz resonance frequency.

2. The variation of the duration of the magnetic field makes it possible to scan a wide range of resonance frequencies of the cell culture. The process would be like tuning a radio. At special frequencies resonant coupling to the frequency of magnetic field and to the frequency defined by the duration of magnetic field becomes possible and enhanced dark photon emissions take place. If the fundamental frequency were not varied, the effect would occur only for very special pulse durations.

3. Why the visible photons were observed only during the beginning of DI phase? If the emitted photons were dark having very long wave length but energy of visible photon, they would not have been detected during AD phase. The decay of dark photons after the beginning of DI phase to bunches of ordinary photons could explain the observed enhanced emissions of visible photons.

6.3.4 Why The Magnetic Pulses From A Given Direction Arrived With Frequency Of 10 Hz?

The magnetic pulses arriving from a given direction to the cell culture dish/LED came with a frequency of 10 Hz. That a fundamental biorhythm is in question, cannot be an accident. In TGD framework 10 Hz frequency corresponds to the secondary p-adic time scale assignable to electron and defines the size scale of causal diamond assigned with electron. This conforms with the assumption that electronic Cooper pairs are fundamental for consciousness serving also as carriers of super-current through cell membrane. In fact, all elementary particles correspond in zero energy ontology to macroscopic time scales via the secondary p-adic time scales associated with them and for quarks the time scales correspond to frequencies of order 10 ms.

6.4 Third Article

Third article has the title *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.*

In the third article (see `http://tinyurl.com/ya4yb6bc`) [**?**] the group reports excess correlation of brain activity of individual subjects separated by 300 km and sharing the same circular rotating, angular accelerating magnetic fields.

According to the article's abstract,

> in order to test the presence of excess correlation, or entanglement, pairs of subjects separated by 300 km were either exposed or not exposed to specific configurations of

circular magnetic fields with changing angular velocities that dissociated the phase and group components. When one person in the pair was exposed to sound pulses but not to light flash frequencies within the classical electroencephalographic band, there were discrete changes in power within the cerebral space of the other person even though they were not aware of the stimulus times and separated by 300 km. The intracerebral changes that only occurred if the magnetic fields were activated around the two cerebrums simultaneously were discrete and involved about single, punctate volumes of about 0.13 cc (125 mm^3). The potential energy from the applied magnetic field within this volume was calculated to be about 6×10^{-14} J and with an average brain power frequency of 10 Hz would result in 6×10^{-13} W. Assuming $\pi \cdot 10^{-2}$ m^2 for the surface area of the cerebrum, this is equivalent to $\sim 2 \cdot 10^{-11}$ Wm^{-2}. This power density is the same order of magnitude as that associated with photon emission during cognition. Given the average of 6×10^6 neurons per 125 mm^3, the induced energy is equivalent to about 10^{-20} J per neuron. This value can be considered a quantum of universal energy and would be congruent with a condition that could promote non-locality.

6.4.1 Experimental Arrangement And Results

If I have understood correctly, the experimental arrangement was roughly following.

1. Two individual subjects were involved. The second subject was 300 km away. The other subject received stimuli at various frequencies of sound or flashes of light while the first person was unaware of these stimuli. Both members of the pair were exposed to a rotating, circular magnetic field whose frequency modulation would vary with rotation angle. This guarantees that the phase and group velocities of the magnetic field varied and were different.

2. It seems safe to assume that the magnetic field pattern used to stimulate brains of subject persons was identical with that applied in the second experiment.

Authors report a correlation between individual subjects in the sense that there were discrete changes in EEG power within the cerebral space of the second person even if he/she was not aware of the stimulus. The effect occurred only if the phase and group velocities assignable to the magnetic field were different. Authors interpret this as entanglement identified as excess correlation if the fields were activated around cerebrum simultaneously and were discrete and involved about single punctuate volumes of about 125 mm^3. Entanglement in this sense need not correspond to quantum entanglement although it could make it possible.

Authors introduce what they call quantum universal energy $E = 10^{-20}$ J, and estimate the that this is the induced energy per neuron transferred from the magnetic field to energy of EEG. In particle physicist's units this gives $E = 6.24 \times 10^{-2}$ eV. This would naturally correspond to energy gained by electron or proton in the resting potential E_{rest}, which is above $E_{min} = 6.15 \times 10^{-2}$ eV. Note that threshold potential for nerve pulse generation corresponds to energy $E_{thr} = 5.5 \times 10^{-2}$ eV. On the other hand, also the first experiment and precedessor of the second experiment involved visible photon emissions which suggests that also visible photons were emitted and they came from the transitions of the proton spin network associated with cell membrane proposed by Wu and Hu [**?**].

6.4.2 TGD Based Interpretation

TGD interpretation should rely on the notion of magnetic body and a model for neuronal membrane as a super-conductor - at least electronic but possibly also ionic super-conductor), cyclotron Bose-Einstein condensed of biologically important ions, and the spin network of dark protons associated with the cell membrane discussed in TGD based model for the outcome of the experiment described in the first article.

1. The flux tubes of the rotating magnetic field would connect the subject persons into a single coherent unit reacting to the stimuli posed to second subject like a single unit. TGD assigns to the magnetic bodies large effective value of Planck constant so that photons with energies of order E would correspond to much longer wavelengths essential for the coherence in scales of the order of a few wave lengths.

2. The wave length $\lambda = 300$ km could correspond to the Planck constant $\hbar_{eff} \simeq \lambda/\lambda_0 = 1.5 \times 10^{10} \times \hbar$, where one has $\lambda_0 = c/E\hbar \simeq 20$ μm is the wavelength of photon with "quantum universal energy". This energy is in IR region just around thermal threshold. The corresponding period and frequency are $T = c/\lambda = 1$ ms and $f = 1$ kHz, which correspond to fundamental time scales for cell membrane with 1 ms defining the time scale of nerve pulse and 1 kHz defining an important resonance frequency in brain associated with the generation of coherence. Probably this is not an accident. The authors indeed mention that the effect is maximal at distance of 300 km.

Concerning the detailed interpretation of the experiment there are several options. First, TGD suggests two alternative models for cell membrane as Josephson junction involving currents of electron Cooper pairs and possibly also bosonic ions or Cooper pairs of fermionic ions. For the conservative option the cell membrane would be far-from- vacuum extremal carrying strong induced Kähler field. For the non-conservative option the cell membrane would be near-to-vacuum extremal making it maximally sensitive to sensory input. Secondly, the universal quantum suggests emission of dark IR photons, whereas the emission of visible photons associated with cognition suggests visible photons.

1. The "quantum universal energy" $E = eV_{rest} = 6.24 \times 10^{-2}$ eV would naturally correspond to the energy gained by electron or proton in a membrane potential slightly above the threshold potential. Also the conservative option for cell membrane as Josephson junction would predict Josephson radiation emitted at multiples of Josephson frequency $E = eV_{rest}$ or $E = eE_{thr}$.

2. The non-conservative option for the cell membrane as Josephson junction predicts that the emitted photons have visible energies. This option might be realized for photoreceptors in retina, which react to the sensory stimulus by variation of membrane potential instead of nerve pulse. The correlation of cognition with the emission of visible photons also allows one to consider the possibility that some neurons are near-to-vacuum extremals (also glial cells as cells which do not generate nerve pulses could be such). Since visible photon emissions are mostly from the right hemisphere, one can ask whether the emissions from the left hemisphere are in IR region and those from right hemisphere in visible region and whether the different ground states of neurons as far-from- respectively near-to- vacuum extremals could distinguish between right and left hemisphere.

3. How does the spin network model based on dark proton strings relate to this? Since the photons have biological functions, the energies of all kinds of EEG photons should be in the same region of spectrum: visible or IR for a given hemisphere. For near-to-vacuum extremals the argument of Hu and Wu would be modified by replacing ordinary magnetic field with a combination of Z^0 magnetic field and ordinary magnetic field. This would imply that the energy scale would increase just as it does when Z^0 electric field dominates over em electric field. Therefore also the photons emitted by spin network at the right hemisphere would be dark EEG photons with energies of visible photons.

4. An alternative interpretation encouraged by the photon emission associated with cognition is that λ_0 corresponds to the energy of visible photon resulting in the transformation of dark ELF photon produced in the triplet-to-singlet transition of proton pair associated with the cell membrane as described in the interpretation of the first experiment. For a photon with energy 1.77 eV at the red end of visible spectrum this would give $\hbar_{eff} = 4.3 \times 10^{11}$. Interestingly, Cyril Smith [I16] reports on the basis of his own experimentation that the transformation of low energy photons to high energy photons and vice versa takes place for frequency ratio $f_h/f_l = 2 \times 10^{11}$: the interpretation would be also in this case in terms of $\hbar_{eff}$ [K49].

6.5 Conclusions

The results of the experiments of Persinger *et al* can be understood in the framework of TGD and the findings allow to develop a more precise view about the role of dark electrons, protons, and ions in TGD inspired quantum biology.

1. The identification of the magnetic flux quanta connecting two systems as generators of macroscopic quantum coherence finds experimental support.

2. The proposal of Hu and Wu about proton spin networks associated with cell membrane has a TGD counterpart in terms of dark proton strings allowing interpretation as dark DNA. The spin-paired protons are assigned to the hydro-philic ends of the two lipids in the layers of the cell membrane and the dark proton strings define an analog of DNA double strand. The model of Wu and Hu is subject to the same objections as the model for cyclotron Bose-Einstein condensates and is circumvented by introducing the hierarchy of effective Planck constants.

3. The fact that photon emissions are detected only from the right hemisphere suggests that both options for the cell membrane as Josephson junction are realized: far-from-vacuum extremal option for the neurons of the left hemisphere with emissions in infrared and near-to vacuum extremal for the neurons of the right hemisphere.

To sum up, the resulting framework allows an overall view about the roles of both dark electrons, dark protons, and dark ions in quantum biology according to TGD.

Part II

QUANTUM MODEL FOR EEG AND NERVE PULSE

Chapter 7

Dark Matter Hierarchy and Hierarchy of EEGs

7.1 Introduction

The emergence of zero energy ontology, the explanation of dark matter in terms of a hierarchy of Planck constants requiring a generalization of the notion of embedding space, the view about life as something in the intersection of real and p-adic worlds, and the notion of number theoretic entanglement negentropy led to a breakthrough in TGD inspired quantum biology and also to the recent view of qualia and sensory representations including hearing allowing a precise quantitative model at the level of cell membrane.

Also long range weak forces play a key role. 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 standard ground state classical Z^0 fields are very weak. This leads to a correct prediction for the frequencies of peak sensitivity for photoreceptors - something highly non-trivial remembering that also the large parity breaking effects in living matter find a natural explanation. It must be however emphasizef that there is also alternative model of Josephson junctions which seems to provide a better explanation for the role of protons in metabolism. Second quantitative key observation was that for electrons and quarks the time scales of causal diamonds correspond to fundamental biorhythms assignable to central nervous system.

The general model for EEG follows neatly from this picture combined with the general model of high T_c superconductivity. A fractal hierarchy of EEGs and its generalizations identified in terms of Josephson radiation is predicted with levels labeled by p-adic length scales and the value of $\hbar$ at various levels of dark matter hierarchy: the recent view about the generalization of the notion of embedding space realizing this hierarchy is discussed in the Appendix. Cell membrane would represent only one level in this hierarchy. The analogs of EEG would exist for various organs, organelles and even cell. Also the possibility of ZEG, WEG and QEG corresponding to Z^0 bosons, W bosons, and gluons must be considered.

7.1.1 Background Ideas

Zero energy ontology

Zero energy ontology meant a breakthrough in the understanding of TGD and TGD inspired theory of consciousness and biology.

In zero energy ontology the S-matrix is generalized to M-matrix defining entanglement coefficients between positive and negative energy parts of zero energy states [K27]. M-matrix has interpretation as a "complex square root" of density matrix and thus provides a unification of thermodynamics and quantum theory. S-matrix is analogous to the phase of Schrödinger amplitude multiplying positive and real square root of density matrix analogous to the modulus of Schrödinger amplitude.

The notion of finite measurement resolution realized in terms of inclusions of von Neumann algebras allows to demonstrate that the irreducible components of M-matrix are unique and

possesses huge symmetries in the sense that the hermitian elements of included factor $\mathcal{N} \subset \mathcal{M}$ defining the measurement resolution act as symmetries of M-matrix, which suggests a connection with integrable quantum field theories.

Zero energy ontology is consistent with the ordinary positive energy ontology when the time scale T characterizing CD is long as compared to the time scale of observations. For shorter times scales however creation of matter from vacuum having in standard QFT framework interpretation as quantum fluctuations becomes possible and this process might occurs routinely in living matter unless the values of Planck constant assignable to CDs are very large. Also CDs can be created in quantum jump and a possible interpretation for a creation of CD is in terms of embedding space correlates of selves and of directed attention generating mental images. This interpretation leads to a model explaining how the arrow of psychological time emerges and why the contents of sensory experience are in so narrow time interval. The unexpected prediction is that zero energy ontology assigns to elementary particles macroscopic times scales. In particular, the time scales assignable to electron, d, and u quarks correspond to the frequencies 10 Hz (fundamental biorhythm), 1280 Hz (kHz cortical synchrony), and 160 Hz (cerebellar synchrony).

Systematic mistake in the identification of p-adic lengths scales above electron length scale

Before going to the topic it should be confessed that the identification of p-adic length scales and times above that defined by electron has been plagued by a systematic error appearing in all writings before 2014. This mistake 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.

p-Adic length scale hypothesis and biology

The basic implication of zero energy ontology is the formula $T_2(k) = T(k) \simeq 2^{k/2}L(k)/c = L(2,k)/c$ for the secondary p-adic time scale for $p \simeq 2^k$. This would be the analog of $E = hf$ in quantum

mechanics and together hierarchy of Planck constants would imply a direct connection between elementary particle physics and macroscopic physics. Especially important this connection would be in macroscopic quantum systems, say for Bose Einstein condensates of Cooper pairs, whose signature the rhythms with $T(k)$ as period would be. The presence of this kind of rhythms might even allow to deduce the existence of Bose-Einstein condensates of hitherto unknown particles.

Unfortunately, the mistake in the identification of the p-adic length scales above electron scale forces to modify the definition of $T(k)$ by introducing a $\sqrt{5+X}$ factor so that it becomes the secondary Compton time scale of electron in the p-adic length scale considered. Writing this explicitly, one has $T_e(k) \equiv T_{2,e}(k) = 2^{k-127}T_{2,e}(127) \equiv 2^{k-127}T_e(127)$. Apologies for a loose notation replacing subscript "2, e" with "e".

1. For electron secondary Compton time equal to $T_e(k) = .1$ seconds defines the fundamental $f_e = 10$ Hz bio-rhythm appearing as a peak frequency in alpha band. This could be seen as a direct evidence for a Bose-Einstein condensate of Cooper pairs of high T_c super-conductivity. That transition to "creative" states of mind involving transition to resonance in alpha band might be seen as evidence for formation of large BE condensates of electron Cooper pairs.

2. TGD based model for atomic nucleus [L4] predicts that nucleons are connected by flux tubes having at their ends light quarks and anti-quarks with masses not too far from electron mass. The corresponding p-adic frequencies $f_q = 2^k f_e$ could serve as a biological signature of exotic quarks connecting nucleons to nuclear strings. $k_q = 118$ suggested by nuclear string model would give $f_q = 2^{18} f_e = 26.2$ Hz. Schumann resonances are around 7.8, 14.3, 20.8, 27.3 and 33.8 Hz and f_q is not too far from 27.3 Hz Schumann resonance and the cyclotron frequency $f_c(^{11}B^+) = 27.3$ Hz for $B = .2$ Gauss explaining the effects of ELF em fields on vertebrate brain.

3. For a given $T_e(k)$ the harmonics of the fundamental frequency $f = 1/T(k)$ are predicted as special time scales. Also resonance like phenomena might present. In the case of cyclotron frequencies they would favor values of magnetic field for which the resonance condition is achieved. The magnetic field which in case of electron gives cyclotron frequency equal to 10 Hz is $B_e \simeq 3.03$ nT. For ion with charge Z and mass number A the magnetic field would be $B_I = \frac{A}{Z}(m_p/m_e)B_e$. The $B = .2$ Gauss magnetic field explaining the findings about effects of ELF em fields on vertebrate brain is near to B_I for ions with f_c alpha band. Hence the value of B could be understood in terms of resonance with electronic B-E condensate.

4. The hierarchy of Planck constants predicts additional time scales $T_e(k)$. The prediction depends on the strength of the additional assumptions made. One could have scales of form $nT(k)$. Integers n could correspond to ruler and compass integers expressible as products of first powers of Fermat primes and power of 2. There are only four known Fermat primes so that one has $n = 2^n \prod_i F_i$, $F_i \in \{3, 5, 17, 257, 2^{16}+1\}$. In the first approximation only 3- and 5- and 17-multiples of 2-adic length scales would result besides 2-adic length scales.

5. Mersenne primes are expected to define the most important fundamental p-adic time scales. The list of real and Gaussian (complex) Mersennes M_n possibly relevant for biology is given by n=89, 107, 113*, 127, 151*, 157*, 163*, 167* (* tells that Gaussian Mersenne is in question).

n	89	107	113	127
f_e/Hz	2.7×10^{12}	1.0×10^7	1.6×10^5	10
n	151	157	163	167
T	19.4 d	3.40 y	218.0 y	3.49×10^3 y

(7.1.1)

Mersenne hypothesis

The scale of the Josephson frequencies assignable to a given neuron is determined by the value 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.

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 p-adic length scales $L_e(k)$ with $k \in \{151, 157, 163, 167\}$ are in the biologically highly interesting range 10 nm-2.5 μm). Of course, $L(k) = L_e(k)/\sqrt{5}$ also are in biologically interesting length scale range. 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 $r = 2^{k_d}$, $k_d = k_i - k_j$.

This proposal will be referred to as Mersenne hypothesis and it leads to strong predictions about EEG since it predicts a spectrum of preferred Josephson frequencies for a given value of membrane potential and also assigns to given value of $\hbar$ a fixed size scale having interpretations as size scale of body part or magnetic body.

DNA and topological quantum computation

The model of DNA as topological quantum computer led to a dramatic progress in the understanding of how magnetic body interacts with the biological body. The model which looks the most plausible one relies on two specific ideas.

1. Sharing of labor means conjugate DNA would do TQC and DNA would "print" the outcome of TQC in terms of RNA yielding amino-acids in the case of exons. RNA could result in the case of introns. The experience about computers and the general vision provided by TGD suggests that introns could express the outcome of TQC also electromagnetically in terms of standardized field patterns. Also speech would be a form of gene expression. The quantum states braid would entangle with characteristic gene expressions.

2. The manipulation of braid strands transversal to DNA must take place at 2-D surface. The ends of the space-like braid are dancers whose dancing pattern defines the time-like braid, the running of classical TQC program. Space-like braid represents memory storage and TQC program is automatically written to memory during the TQC. The inner membrane of the nuclear envelope and cell membrane with entire endoplasmic reticulum included are good candidates for dancing halls. The 2-surfaces containing the ends of the hydrophobic ends of lipids could be the parquets and lipids the dancers. This picture seems to make sense.

One ends up to the model also in top-down way.

1. Darwinian selection for which 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.

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.

4. Fluid flow must 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.

5. The topology of the braid traversing cell membrane cannot not 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.

6. There are several problems related to the details of the realization. How nucleotides A,T,C,G are coded to strand color and what this color corresponds to? One can imagine several possibilities [K108] and the vision about DNA as topological quantum computer [K2] suggests that genetic code is indeed represented in several way. One of them predicts that wormhole contacts carrying quark and anti-quark at their ends appear in all length scales in TGD Universe. How to split the braid strands in a controlled way? High T_c super conductivity provides the 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. How magnetic flux tubes can be cut without breaking the conservation of the magnetic flux? The notion of wormhole magnetic field saves the situation now: after the splitting the flux returns back along the second space-time sheet of wormhole magnetic field. The model inspires several testable hypothesis about DNA itself: in particular, the notion of anomalous em charge of DNA leads to several predictions of this kind. Also new mechanisms of catalytic action based on phase transitions reducing the value of Planck constant emerge.

Summary of basic ideas leading to the model of EEG

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 [K2]. 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 could code for four DNA nucleotides in this model. 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 could code for four DNA nucleotides in this model. There are also other options. In particular, the states of dark proton are in one-one correspondence with DNA, RNA, amino-acids and possibly also tRNA, and vertebrate genetic code is realized as a natural mapping between DNA and amino-acid like states [L4, K49]. This coding would map entire dark DNA codons to dark amino-acids, and one cannot reduce the code words to separate letters since quarks are quantum entangled.

2. Zero energy ontology assigns to elementary particles so called causal diamonds (CDs). For u and d quarks and electron the Compton time time scales are (6.5,.78, 100) ms respectively, and correspond to fundamental biorhythms. As already noticed, secondary electron Compton time corresponds to 10 Hz fundamental biorhythm defining also the fundamental

frequency of speech organs,.78 ms to kHz cortical synchrony [**?**]. and 160 Hz to cerebellar synchrony [**?**]. 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 [K79] remain to be disentangled.

3. The understanding of the Negentropy Maximization Principle [K61] and the role of negentropic 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 become basic aspects of conscious intelligence and are expected to be especially important for understanding the difference between speech and music.

The model of sensory receptor

One can think of two alternative models for sensory receptor. The first model for sensory receptor identifies cell membrane as almost vacuum extremal.

1. It has been clear from the beginning that the nearly vacuum extremals of Kähler action could play key role key role in living systems. The reason is their criticality making them ideal systems for sensory perception. These extremals carry classical em and Z^0 fields related to each other by a constant factor and this could explain the large parity breaking effects characterizing living matter. The assumption that cell membranes are nearly vacuum extremals and that nuclei can feed their Z^0 charges to this kind of space-time sheets (not true for atomic electrons) in living matter leads to a modification of the model for the cell membrane as Josephson junction [K79]. Also a model of photoreceptors explaining the frequencies of peak sensitivity as ionic Josephson frequencies and allowing the dual identifications Josephson radiation as bio-photons (energies) [I36] and EEG radiation (frequencies) emerge since the values of Planck constant can be very large.

2. The value of the Weinberg angle in this phase is fixed to $sin^2(\theta_W) = .0295$, whereas in standard phase the value is given by $sin^2(\theta_W) = .23$. This assumption of course might be criticized and is probably unrealistic. It can be given up if the effective cell membrane potential depends on the receptor of particular ion. Also the argument behind the conclusion about Weinberg angle is rather weak being based on rather ad hoc identification of the energies of photons with peak sensitivity as generalized Josephson energies assignable to specific dark ions.

Second model identifies cell membrane as far from vacuum extremal and is supported by the findings of Pollack about water as a fourth phase of water. This model forces generalization of Josephson junction so that Josephson energy as increment of Coulombic energy is replaced with its sum with the difference of cyclotron energies defining the TGD counterpart of the chemical potential in the thermodynamical model which in Zero Energy Ontology is replaced with its "square root". This model is also consistent with the TGD views about metabolism and bio-photons and also provides a mechanism for the generation of nerve pulse.

In microscopic description one must consider transmembrane proteins as Josephson junctions and one could argue that they can be either near to vacuum extremals or far from vacuum extremals but that both states are are not possible.

The ensuing general model of how cell membrane acts as a sensory receptor has unexpected implications for the entire TGD inspired view about biology.

1. DNA as topological quantum computer model plus certain simplifying assumption leads to the conclusion that the spectrum of net quantum numbers of quark antiquark pair define the primary qualia assignable to a nucleotide-lipid pair connected by a magnetic flux tube. The most general prediction is that the net quantum numbers of two quark pairs characterize the qualia. In the latter case the qualia would be assigned to a pair of receptor cells.

2. Composite qualia result when one allows the nucleotide-lipid pairs of the membrane to be characterized by a distribution of quark-antiquark pairs. Cell membrane -or at least the axonal parts of neurons- would define a sensory representation in which is a pair of this kind defines a pixel characterized by primary qualia. Cells would be sensory homunculi and DNA defines a sensory hologram of body of or of part of it. Among other things this would give a precise content to the notion of grandma cell.

3. (Generalized) Josephson frequencies or assignable to biologically important ions are in one-one correspondence with the qualia and (generalized) Josephson radiation could re-generate the qualia or map them to different qualia in a one-one and synesthetic way in the neurons of the sensory pathway. For large values of Planck constant Josephson frequencies are in EEG range so that a direct connection with EEG emerges and Josephson radiation indeed corresponds to both bio-photons and EEG. This would realize the notion of sensory pathway which originally seemed to me a highly non-realistic notion and led to the vision that sensory qualia can be realized only at the level of sensory organs in TGD framework.

4. At the level of brain motor action and sensory perception look like reversals of each other. In zero energy ontology motor action this analogy can be justified so that the model of sensory representations implies also a model for motor action. Magnetic body serves as a sensory canvas where cyclotron transitions induced by Josephson frequencies induce conscious sensory map entangling the points of the magnetic body with brain and body.

7.1.2 Vision About Eeg

The general model for EEG relies on the idea that EEG frequencies correspond to Josephson frequencies defined by membrane potentials and provide cognitive and one might also say emotional representation of the sensory input at the magnetic body in terms of cyclotron transitions. The perturbations of the membrane potentials caused by spikes, neurotransmitters affecting alertness reducing the magnitude of the resting potential induced frequency modulations of the membrane potentials and one can say that the cell is like a singing whale with evoked potentials and nerve pulse patterns coded to the varying frequency. Song is expression of this singing but also speech involves frequency modulation as one learns by playing slowly recorded spoken language.

The scale of the frequency assignable to a given neuron is determined by the value 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.

An essential assumption is that cell membrane corresponds to almost vacuum extremal so that classical Z^0 field proportional to em field is present and leads to the replacement of ionic charges with effective charges much larger than ionic charges so that that membrane voltage corresponds to a photon energy in visible or UV range and the energies of biologically most important ions span half octave.

Armed with this picture one ends upd with a rather detailed quantitative model for EEG. In this chapter this model is applied in more detail. Features, synchronization, stochastic resonance, temporal codings, and what I have used to called scaling will be discussed.

7.1.3 Fractal Hierarchy Of Generalizations Of Eeg

EEG is replaced with a fractal hierarchy of generalizations of EEG corresponding to various values of Planck constants involved and to what kind of part of living system the magnetic body in question corresponds.

1. There are three contributions to EEG besides the contributions due to the neural noise and evoked potentials. These contributions correspond to Schumann frequencies, cyclotron frequencies f_c of biologically important ions in magnetic field $B_{end} = .2$ Gauss and its $1/\hbar$ scaled counterparts, and to the Josephson frequencies f_J associated with Josephson junctions assigned with cell membranes. If Josephson radiation modulates cyclotron radiation also the frqequencies $mf_J \pm nf_c$ appear in the spectrum.

2. In standard model $f_J = ZeV/\hbar$ would determined by the membrane potential and would correspond to energy in infrared. This sounds completely reasonable. TGD however suggests that cell membrane as a critical system correspond to an almost vacuum extremal. This predicts classical Z^0 field proportional to em field to which nuclei and neutrinos are assumed to couple. This would explain chiral selection in living matter and predict correctly the frequencies of peak sensitivity for photoreceptors as Josephson frequencies assignable to the biologically most important ions. The effective couplings of ions to membrane potential are modified and the Josephson frequencies correspond to energies in visible and UV range. Bio-photons and EEG could be seen as manifestations of one and same thing: Josephson radiation with a large value of Planck constant with energies of bio-photons and frequencies of EEG.

3. An important point is that the ions involved must behave like bosons. For cyclotron condensates either Cooper pairs of ordinary fermionic ions or exotic ions chemically similar to their standard counterparts obtained from neutral bosonic atom by making one or more neutral color flux tubes connecting nucleons charged. For Josephson radiation only the latter option works. TGD based nuclear physics indeed predicts this kind of nuclei and there is experimental evidence for their existence [L4]. [L4].

4. For cyclotron frequencies the extremals are assumed to be far from vacuum extremals carrying very small classical Z^0 fields but non-vanishing classical W fields and color fields (with $U(1)$ holonomy). The corresponding flux quanta would naturally correspond to flux sheets traversing through DNA strands while Josephson radiation would propagate along flux tubes parallel to the cell membrane. Far from biological body one expects both kinds of flux quanta to fuse to form larger ones so that one has parallel space-time sheets carrying cyclotron *resp.* Josephson radiation. Wormhole contacts between Josephson and cyclotron flux sheets would induce a non-linear interaction giving rise to a superposition of harmonics of Josephson and cyclotron frequencies.

5. Josephson frequencies are assignable to the cell membrane and would naturally correspond to the communication of sensory data to the magnetic body. This would suggest that cyclotron frequencies are assignable to the magnetic flux sheets going through DNA strands responsible for quantum control via gene expression. This picture might be too naive. Josephson radiation would induce transitions between cyclotron states should generate sensory representations at magnetic body so that both frequencies would be involved with sensory representations. Furthermore, the identification of motor action as time reversal of sensory perception allowed by zero energy ontology would mean that same mechanisms are at work for negative energies (phase conjugate radiation). Resonance is achieved if the condition $mf_J = nf_c$ is satisfied. For small values of integers m and n the condition is quite restrictive. Schumann frequencies can be assigned with the magnetic body of Earth and would correlate with the collective aspects of consciousness.

6. The model of hearing forces to assume quite a wide spectrum of Planck constants- at least the values coming as powers of two and the safest assumption is that at least integer multiples of the ordinary Planck constant are possible. Josephson radiation and cyclotron radiation have same scale if $B_{end} \propto 1/\hbar$ proportionality holds true. Note that for 5 Hz Josephson frequency

and membrane potential and for $V = . - 70$ mV corresponding to the resting potential of neuron one obtains $r = (0.96, 1.20, 1.34, 1.01) \times 2^{47}$ for almost vacuum extremals. For Ca^{++} ion r is very near to a power of 2.

7.1.4 Basic Aspects Of Eeg

Consider now how one could understand basic characteristics of EEG during wake-up and sleep in this framework.

1. For small amplitudes and for the lowest harmonics this implies that alpha band to which the cyclotron frequencies most biologically important bosonic ions corresponds has as satellites theta and beta bands. Higher harmonics correspond to gamma and higher bands having also satellites.

2. For large amplitudes EEG becomes chaotic which is indeed the property of beta band during say intense concentration or anxiety. The findings of Nunez about narrow 1-2 Hz wide bands at 3,5,7 Hz and 13,15,17 Hz confirm with the prediction of satellite bands and fix the Josephson frequency to 5 Hz. This picture explains the general characteristics of EEG in wake-up state qualitatively and quantitatively.

3. In order to understand the characteristics during various stages of deep sleep one must assume that the cyclotron frequency scale of ions is scaled down by a factor of 1/2. The simplest explanation is that the value of Planck constant increases by a factor 2 in a phase transition having interpretation as a leakage of cell membrane space-time sheet between the pages of Big Book defined by the generalized embedding space. During stage 4 sleep only only DNA cyclotron frequencies in delta band are around 1 Hz and just above the thermal threshold are predicted to be present. This stage could correspond to a value of Planck constant which is 4 times its value in wake-up state.

The generalization of the model for EEG hierarchy to the case of ZEGs is straightforward and Josephson frequency spectrum is the same. Any atom, almost always boson, has an exotically charged counterpart with same statistics so that very rich spectrum of Bose-Einstein condensates results.

7.1.5 The Effects Of ELFEM Fields On Brain

The experimental data about the effects of ELF em fields at cyclotron frequencies of various ions in Earth's magnetic field on vertebrate brains were crucial for the development of the model of EEG. As a matter fact, it was the attempt to explain these effects, which eventually led to the discovery of the fractal hierarchy of EEGs and its generalizations. These effects therefore serve as a killer test for the scenario and are still only partially understood.

The reported effects occur for harmonics of cyclotron frequencies of biologically important ions in Earth's magnetic field. They occur only in amplitude windows. The first one is around 10^{-7} V/m and second corresponds to the range $1 - 10$ V/m: the amplitudes of EEG waves are in the range 5-10 V/m. The effects are present only in the temperature interval 36-37 C.

1. Cyclotron frqeuencies led to the vision about cyclotron condensates of biologically important ions and their Cooper pairs at the flux quanta of dark magnetic field with so large Planck constant that the energies of cyclotron photons are above thermal threshold. The model for EEG and bio-photons in terms of Josephson radiation from cell membrane which is almost vacuum extremal allows to make this model more quantitative.

2. The temperature window has one interpretation in terms of a competion of almost vacuum extremal property of cell membrane possible above some critical temperature and high T_c super-conductivity possible below some critical temperature.

3. The amplitude window 10^{-7} V/m follows from a quantized form of Faraday law whose existence is supported by the fact that space-time sheets are analogs of Bohr orbits in exact sene. The quantisation condition relates the amplitude of electric field to Planck constant

and frequency. For the value $r = \hbar/\hbar_0 = 2^{47}$ of Planck constant required by 5 Hz Josephson frequency the 10^{-7} V/m amplitude is predicted correctly.

4. The amplitude window around 1-10 V/m (EEG amplitudes are in the range 5-10 V/m) follows if the values of Planck constant in the range $10^7 r - 10^8 r$ can be justified. A possible justification is based on the observation that for $r_1 = 10^8 r$ the Compton wave length of intermediate gauge bosons corresponds to $k = 163$ defining Gaussian Mersenne and wavelength nearly that corresponding to 2 eV energy, which also corresponds to bio-photon energies assignable to 50 mV subcritical membrane potential. 1-10 V/m interval corresponds roughly to the range of bio-photon energies. Electron's Compton length corresponds for $r_1 = 10^8 r$ to 28 cm, which defines the size scale of brain. One might hope that these findings could allow to build an internally consistent story about what happens.

7.1.6 Generalized EEG and Consciousness

If the Josephson radiation for a particular primary sensory organ and corresponding sensory pathway propagates to a specific part of the magnetic body along flux quanta it for sensory qualia. Similar interpretation applies to motor action interpreted formally as sensory perception in reversed time direction. Note that the resting potential for the cell membrane is considerably higher for motor neurons than for sensory receptor neurons. The assumption that Josephson radiation induces cyclotron transitions leads to a general interpretation of the generalized EEG in terms of spectroscopy of consciousness.

1. The primary qualia are coded by quantum numbers of quark pairs (or pairs of them) assignable to the ends of the flux tubes connecting DNA nucleotide and lipids. Sensory input generates the Josephson radiation and induces the primary qualia at the level of sensory receptor. Josephson radiation can also regenerate primary qualia or mental images in one-one correspondence with the primary qualia along the entire sensory pathway. Josephson radiation can transform to either bio-photons or EEG photons.

2. At the magnetic body Josephson radiation induces cyclotron transitions if resonance conditions are satisfied which implies that the communication of sensory data is optimal for special values of cell membrane resting potential for a fixed value of the magnetic field which of course can also vary. The value of resting potential critical for the generation of nerve pulse is the best candidate in this respect.

3. Also cyclotron transitions could correspond to some kind sensory qualia. "General feeling of existence" possibly accompanying all sensory qualia shared by the magnetic body is one possible identification for the quale involved. The quantum entanglement between this kind of mental image and the mental image representing the primary quale is natural candidate for the experience.

7.1.7 Vision About Biological Evolution And Evolution Of Brain

The proposed model for EEG, the idea that Gaussian Mersennes (four of them are in the range 10 nm-2.5 micrometers) define p-adic length scales allowing exotic variants of color and electro-weak physics with light intermediate gauge bosons at space-time sheets near vacuum extremals, and the assumption that the preferred values of Planck constant are such that they relate these p-adic scales to each other leads to a detailed quantitative vision about evolution of life as emergence of longer scales belonging to this hierarchy and as special case also to a vision about evolution of cell, nervous system, EEG, and long term memory. The model predicts a hierarchy of preferred size scales for various sub-systems of organisms and corresponding time scales identifiable in terms of bio-rhythms and memory span.

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` [L14].

7.2 What Is EEG Made Of?

The usual classification of EEG frequencies by EEG bands is more or less a convention and the definitions of various bands vary in frustratingly wide ranges. In a more ambitious approach bands should be replaced with some substructures identified on basis of their physical origin and function. In the proposed framework this is possible. This identification of substructures of course applies only to that part of EEG from which evoked potentials, noise, and possible other contributions are subtracted.

7.2.1 Basic Ingredients For Dark Hierarchy Of EEGs

The dark hierarchy of Josephson junctions with fixed size characterized by a p-adic length scale most naturally assignable to a member of twin prime pair defining a fractal hierarchy of EEG like spectra assignable to various parts of organism is the basic element of the model of generalized EEG. In the following only ordinary EEG is considered.

The path to recent view

The most obvious guess is that Josephson radiation is used for communications from cell membrane to magnetic body, its absorption induces cyclotron transitions, and the feedback to genome induces cyclotron transitions at the level of DNA inducing DNA expressions. This is of course only the simplest guess: one must start somewhere.

There are indeed objections against this view but the notions of magnetic body, dark matter has hierarchy of phases with non-standard value of Planck constant, and zero energy ontology solve these problems as the construction of a model for the findings of Pollack demonstrated [L16].

1. If one assumes that bio-photons are outcome from transformations of dark EEG photons to visible photons, one encounters a problem since the energies of bio-photons are in visible and UV range unlikes the Josephson photons from cell membrane with energy $E_J = ZeV$ in the range.1-.16 eV for $Z = 2$.

   The earlier proposal for the solution of this problem was that cell membranes can be near vacuum extremal so that classical Z^0 force gives dominating contribution to the membrane potential and increases it so that Coulombic energy has correct order of magnitude. This proposal emerged from a model for color qualia. The problem was that one had to assume for Weinberg angle a value about 1/10 from the standard model value.

2. The nominal value of metabolic quantum is about.5 eV and much larger than the Josephson energy $E_J = .1 - .16$ eV so that one cannot assume that mitochondrial membrane is battery unless there is large chemical potential or some additional contribution to single particle energy.

   In the case of proton Z^0 potential is negligible so that near vacuum extremal property does not solve the problem.

3. In the thermodynamical model of cell membrane and metabolism chemical potentials dominate over Coulomb energy.

   Zero energy ontology means that quantum theory in TGD sense is square root of thermodynamics. This leads to a modification of the thermodynamical model of cell membrane but chemical potential replaced with cyclotron energy of dark matter particle at magnetic flux tube. Also in the thermodynamical model the chemical potential would be replaced by cyclotron energy.

   This model gives hopes of resolving the listed problems. The model has as physical parameters bio-photon energy E_{bio} equal to energy of dark photon, $E_J = ZeV$ or equivalently membrane voltage V, and masses m_i and charges Z_i of charged particles involved, and magnetic field strengths at the portions of the magnetic flux tube at opposite sides of the cell membrane. The octaves of the endogenous magnetic field with value $B_{end} = .2$ Gauss are a good first guess for the values of B. Membrane potential is coded to the generalized Josephson frequency $f = f_{c,I} + f_{J,1}/n$ and the variations of membrane potential give rise to frequency modulation

with $\Delta f/f \sim .1$ which would characterize the width of EEG bands. EEG bands correspond to cyclotron frequencies.

Josephson current

Each junction has a background voltage over it. The basic hierarchy involves the p-adic length scales $L(k)$, $k = 151, 157, 163, 167$ corresponding to Gaussian Mersennes - or to be more precise - the scaled up variants of electron Compton scale for this p-adic scales, which seem to be biologically highly relevant. This suggests the importance of p-adic and dark scales coming in powers of 2. One could consider the possibility that not only $k = 151$ but all these length scales and also twin primes define their own Josephson junctions with their own values of Josephson potential.

Thee model for Josephson current relies on the model of cell membrane inspired by the findings of Pollack.

1. The generalized Josephson current for ion labelled by i can be written as

$$\begin{aligned} J_i &\propto R_{1,i}R_{2,i}sin[\omega_i t + \frac{Z_i e \int V_1 dt)}{\hbar_{eff}}] \ , \\ \omega_i &= \omega_{c,i,1} - \omega_{c,i,2} + \omega_{J,1} - \omega_{J,2} \ , \\ \omega_{J,i,k} = \frac{Z_i e V_k}{\hbar_k}, \ \ k = 1,2 \ , & \\ \omega_{c,i} &= \frac{Z_i e B_{end,i}}{m_i} \\ , R_{i,k} &= exp(\frac{nE_{c,i,k} + Z_i e V_k)}{2T}) \ , \ E_{c,i,k} = h_{eff,i}\omega_{c,i,k} \ , \ n_{i,k} = \frac{h_{eff,i,k}}{h} \end{aligned} \tag{7.2.1}$$

   Here V_k, $k = 1, 2$ denotes electromagnetic potential at the two sides of the membrane and $V = V_1 - V_2$ defines the resting potential. Gauge invariance demands that one can choose $V_2 = 0$ so that one has $V_1 = V$. $R_{i,k}$ denotes the square root of Boltzmann weight defined by cyclotron energy and Josephson energy. T is the physiological temperature.

2. If $n_{i,1} \neq n_{i,2}$ is allowed, the frequency of Josephson radiation is not unique: $\omega_{J,1}/n_{i,1}$ or $\omega_{J,1}/n_{i,2}$. Gauge invariance requires unique Josephson frequency and thus $n_{i,1} = n_{i,2}$ In this case the values of magnetic field B_{end} must differ at the two sides of the cell membrane in order to get radiation with energy scale in that for biophotons. Octave hypothesis for the strength of B_{end} is attractive so that difference of two octaves of $B_{end} = .2$ Gauss would determine E_{bio}.

3. If $E = \hbar_1\omega_1 - \hbar_2\omega_2$ corresponds to bio-photon energy E_{bio} in (possibly IR,) visible or UV range, then the proportionality $h_{eff,i}/h = n \propto A_i$ of h_{eff} to the mass number A_i characterizing the cyclotron frequency of the ion is natural first guess. It implies that

$$E_{bio,i} = h_{eff,i,1}f_1 - h_{eff,i,2}f_2 = h_{eff,i,1}(f_1 - f_2)$$

   depends only weakly on ion (through the additive contribution coming from Josephson energy which is smaller by factor 1/50 roughly).

4. The first guess suggested by octave structure of EEG is that $B_{end,i}$ and cyclotron frequency spectrum becomes in octaves so that spectrum to the cyclotron part of bio-photon energy would come as differences of octaves in the general case. These discrete energy values would be widened to bands with width $\Delta f/f$. The basic prediction is that bio-photon spectrum should reflect rather directly EEG spectrum.

5. There are additional complicacies due to the fact that also the harmonics of ω_i are allowed and the membrane potential is time dependent. EEG spectrum becomes effectively continuous and this reflects itself also in bio-photon spectrum. The membrane potential receives also feedback contribution from magnetic body coming through DNA in the simplest model assuming that magnetic flux tubes in the interior of cell connect it with DNA nucleotides [K2].

Some general comments are in order.

1. Generalized Josephson frequency ω_i would define a kind of drum beat whereas the frequencies associated with V_1 would represent modulation of this drum beat frequency so that the outcome would be like Chopin's piano piece with tempo rubato. ω_i also defines a candidate for the time unit in which the time scale of memories and intentional action of the living system are measured.

2. The phase transitions leading to swelling or contraction of cell can be identified as phase transitions changing the value possible at both sides of the cell and implying that equilibrium concentrations of ions are changed in the manner implied by the generalization of the Boltzmann weight formulas. The modulations of Josephson frequency implied by nerve pulses occur in time scale of few milliseconds and are fast in the time scale defined by cyclotron frequencies and it is quite possible that they modulate electron cyclotron frequency rather than ionic or protonic cyclotron frequencies.

The model for nerve pulse [K79] supports strongly the view that in resting state V corresponds to a propagating soliton sequence associated with Sine-Gordon equation. As described in the section about EEG, the situation is mathematically equivalent to a linear array of gravitational penduli coupling with each other and soliton sequence corresponds to a rotation of penduli with constant phase difference between neighbors so that a propagating wave would result. The analog of EEG would be associated also with ordinary cell membranes but the smaller value of $\hbar$ would imply that the frequencies involved are higher. Non-propagating EEG would accompany neuronal soma and possible propagating EEG waves with axons.

Thermodynamical considerations

The replacement of thermodynamics by its square root required by ZEO has been already explained. The key idea is that the density matrix is replaced with its hermitian square root multiplied by unitary S-matrix. The model of cell membrane would be the first real world application of ZEO.

If cyclotron energies at the two sides of membrane are different and their energy scale is in the range of bio-photons energies or if the membrane is almost vacuum extremal, generalized Josephson energy for ions corresponds to that for a visible or UV photon so that the Josephson photons are well above the thermal energy. The identification of EEG and bio-photons as decay products of large h_{eff} Josephson photons is possible. If the cyclotron energies are different then the generalized Josephson energy is above thermal energy always and Josephson frequency represents only 10 per cent modulation.

Josephson energy should be above thermal energy at physiological temperatures if one allows also the situation in which cyclotron energies are same at the two sides of the cell membrane. The conservative option is that the cell membrane is far from vacuum extremal phase with very small Z^0 field. From the resting potential whose nominal value is often taken to be for.08 V, f_J corresponds roughly to the energy.16 eV whereas the energies allowed by thermal stability must be larger than the energy corresponding to the maximum of black-body radiation intensity distribution as function of frequency and given by $E \simeq 3T_{phys} \simeq .93$ eV at $T_{phys} = 37$ C.

Nerve pulse is generated when the potential drops to about.055 eV: the corresponding Josephson energy for far from vacuum extremal Josephson junction is .11 eV, which is slightly above thermal energy.093 eV so that it seems that metabolic costs are minimized. The energy $E = .1$ eV is the universal transition energy of Cooper pairs of high T_c electronic super conductor [K18].

The generation of nerve pulse should involve h_{eff} changing transitions at either or both sides of the membrane forcing the equilibrium concentrations to change. They might also accompany the transition of the cell from a resting state to active state, which involves folding of the parts of straight unfolded parts of proteins and partial melting of globular proteins due to the melting of ordered water surrounding them.

For organisms possessing no nervous systems, in particular bacteria, this constraint is not relevant.

ZEO thermodynamics should explain why the temperature of brain must be in the narrow range 36-37 C to guarantee optimal functionality of the organism- one of the fundamental mysteries related to living matter.

1. Quantum criticality in some form is expected to be involved. Phase transitions changing the value of Planck constant at the flux tube portions at two sides of cell membrane must be possible. This would induce flows of ions through membrane and swelling and contraction of the cell which are basic phenomena at cell length scale. Phase transitions changing the length of flux tubes would be also involved with bio-catalysis. The possibility of wide spectrum of length scales is indeed key property of critical system. Temperature appears as a parameter in single particle wave functions in ZEO so that there are good changes to understand the thermodynamical aspects of the criticality at the level of first principles.

2. That the ordinary Josephson frequency is very just above the thermal energy should relate to the quantum criticality. If the temperature has too low, the value of h_{eff} is fixed to single value and bio-control - for instance that needed in basic bio-reactions - does not work. Hence h_{eff} changing phase transitions must be possible, and this requires high enough temperature. The temperature cannot be however too high since Josephson energy should be above thermal energy even in the case that cyclotron energies at two sides of the cell membrane are same. Thus biolocical activity and communications to magnetic body are competing factors and lead to a critical range of temperatures.

3. One could say that above critical temperature magnetic body becomes partially blind because communications with ordinary Josephson frequency are not present. Below the critical temperature the biological body becomes lame.

Classification of cyclotron frequencies

Consider now the classification of cyclotron frequencies ($B_{end} = .2$ Gauss will be assumed).

1. Cyclotron frequencies can be classified according to whether they are associated with atomic or molecular ions. For biologically important atomic ions most frequencies are above 7.5 Hz. For molecular ions frequencies are lower and for DNA sequences the frequencies are in delta band rather near 1 Hz irrespective of the length of DNA because the charge is 2 negative charge units per nucleotide.

   Thermal stability condition suggest a lower bound of ~ 1 Hz for significant frequencies of this kind. Thus one can ask whether delta band dominating during deep sleep could correspond to DNA and possibly other bio-molecules and EEG during wake-up state corresponds to atomic ions. For $B_{end} = .2$ Gauss this would require that DNA strands are at magnetic flux tubes and by previous argument at rather large distance from Earth. Interestingly, the large negative charge of DNA makes possible for it to levitate in the Earth's electric field of $E_2 \sim 100$ V/m at the surface of Earth up to heights about 30-50 km and $r \simeq 1.3R_E$. At higher heights this field becomes small or reverses sign.

   O^{2-} is bosonic ion and of special interest because cyclotron frequency is about 37 Hz and near to the thalamo-cortical resonance frequency. O^{2-} also associated with bio-photon emissions so that a connection with EEG is suggestive.

2. Atomic ions can be classified into bosonic and fermionic ions. Practically all biologically important bosonic ions have $Z = 2$ and in alpha band: $f(^6Li^+) = 50$ Hz and $f(Mg^{2+}) = 25$ Hz are the only frequencies above alpha band (see Appendix). Situation is essentially the same for biologically interesting ions. $^7Li^+$ is exception and corresponds to 42.9 Hz. Thus the frequency range $7.5 - 15$ Hz is very strongly represented and expected to be fundamental.

3. The integer n characterizing the harmonics of the cyclotron frequency is an additional classificational criterion and n could correlate with the character of neural processing. The harmonics of Josephson frequency are present in Josephson radiationandinduce resonant cyclotron transitions with arbitrary high values of n if the ratio of Josephson frequency and cyclotron frequency is rational number. Note that the sensory representations at magnetic body are generated only at at critical values of the membrane potential. In case of hearing the values of n would characterize the harmonics of the fundamental and determine the character of the pitch.

4. Also the position in the periodic table of elements provides a classificational criterion (see Appendix) but this criterion does not seem to be so useful as thought originally.

What about electron? The mass ratio m_p/m_e is roughly 2^{-11} so that the cyclotron frequency is by factor about 2^{11} higher. Thus proton and various ions correspond to $h_{eff} = 2^{k+11}A$ and electron to $h_{eff} = 2^k$. This would give some motivation for the original quite too strong hypothesis that the values of h_{eff} come as powers of 2^{11}.

Basic contributions to EEG

The following general overview about quantum communication and control emerges in this framework.

There are three contributions to EEG besides the contributions due to the neural noise and evoked potentials. These contributions correspond to Schumann frequencies, cyclotron frequencies f_c of biologically important ions and Josephson frequencies f_J.

1. Schumann resonances do not depend on magnetic field strengths assignable with the magnetic flux sheets and would characterize Earth's magnetic field and collective aspects of consciousness. According to the model for sensory receptor and magnetic body [K45, K78] the inner rotating part of the Earth's magnetosphere could correspond to the third person aspect of sensory perception whereas the personal magnetic body would be anchored to body and move with it. Both inner and outer magnetosphere (which does not rotate with Earth) could receive sensory input from biosphere.

2. Cyclotron frequencies correspond to magnetic field $B_{end} = .2$ Gauss for the ordinary value of Planck constant and its $1/\hbar$ scaled down counterparts. The extremals are assumed to be far from vacuum extremals carrying very small classical Z^0 fields but non-vanishing classical W fields and color fields (with $U(1)$ holonomy). The corresponding flux quanta would naturally correspond to flux sheets traversing through DNA strands.

3. Josephson frequencies f_J are associated with Josephson junctions assigned with transmembrane proteins. Far from vacuum extremals are assumed. Generalized Josephson frequency is given by $f_i = \Delta f_c + f_{J,1}/n$.

   (a) Bio-photons and EEG can be seen as manifestations of one and same thing: generalized Josephson radiation with a large value of Planck constant with energies of bio-photons and frequencies of EEG. Ordinary EEG photons result when dark visible photon decays into a bunch of ordinary ELF photons and bio-photons result when dark photon transforms to ordinary visible photon. Generalized Josephson radiation would propagate along flux tubes parallel to the cell membrane.

   (b) Generalized Josephson frequencies can be said to code for qualia if the generalized Josephson radiation is guided along magnetic flux tubes to a part of magnetic body specific to a given sensory receptor (or even neuron or cell in the case of cell level qualia). According to the model of sensory receptor [K45, K78] they do not however directly induce the sensory quale, which would be characterized by the net quantum numbers of quark pair (or two of them depending on the model).

   Generalized Josephson radiation can also regenerate the sensory quale along neural pathway. Therefore the original vision about spectroscopy of consciousness is realized in a limited sense. This implies that the precise value of the membrane resting potential could characterize both the parts of the organism and state of consciousness in the case of cortical neurons (say alertness) since depending on the value of membrane potential the neuron is in wake-up state or "sleeps". The value of the membrane potential would also directly correlate with the analog of EEG assignable to the body part. The fact that neuron types correspond to different membrane potentials conforms with this picture and suggest that they also correspond to different magnetic bodies with different field strengths.

4. Far from biological body one expects both kinds of flux quanta to fuse to form larger quanta so that one has parallel space-time sheets carrying cyclotron *resp.* generalized Josephson radiation, whose frequencies are rather near to each other so that flux tube with varying value of B can serve as receiver of the entire spectrum of Josephson radiation for a given ion. Wormhole contacts between Josephson and cyclotron flux sheets would induce a non-linear interaction giving rise to a superposition of harmonics of Josephson and cyclotron frequencies.

How these two kinds of radiations relate to the communication between magnetic and biological body and to the control of biological body by magnetic body is not quite clear.

1. One of the basic functions of the cell membrane is to monitor the chemical environment using various kinds of receptors as sensors. Neurons have specialized to receive symbolic representations of the sensory data of primary sensory organs about the situation in the external world. Receptor proteins would communicate cell level sensory input to the magnetic body via MEs parallel to magnetic flux tubes connecting them to the magnetic body. Josephson frequencies would code various fundamental qualia assignable to DNA nucleotide-lipid pairs so that a sensory map defined by the cell membrane would be communicated to the magnetic body.

2. A good guess is that cyclotron frequencies are assignable to the magnetic flux sheets going through DNA strands responsible for quantum control via gene expression. This guess might be too naïve. Josephson radiation would induce transitions between cyclotron states and generate in this manner sensory representations at magnetic body so that both frequencies would be involved with sensory representations. Furthermore, the identification of motor action as a time reversal of sensory perception allowed by zero energy ontology would mean that the mechanisms of sensory perception are at work for negative energies (phase conjugate radiation). Resonance is achieved if the condition $mf_J = nf_c$ is satisfied. For small values of integers m and n the condition is quite restrictive. Schumann frequencies can be assigned with the magnetic body of Earth and would correlate with the collective aspects of consciousness.

3. The model of hearing forces to assume quite a wide spectrum of Planck constants- at least the values coming as powers of two and the safest assumption is that at least integer multiples of the ordinary Planck constant are possible. Josephson radiation and cyclotron radiation have same scale if $B_{end} \propto 1/\hbar$ proportionality holds true. Note that for 10 Hz cyclotron frequency the estimate for $\hbar$ in the case of 2 eV dark photon is $r \simeq 3 \times 2^{46}$.

Far from critical vacuum extremals allow also classical W fields and gluon fields and they might be relevant for the quantum control via DNA flux sheets.

1. In the length scales below the weak length scale L_w also charged dark weak bosons behave as massless particles and the exchange of virtual W bosons makes possible a non-local charge transfer. For instance, for $\hbar \sim 2^{89}$ W bosons behave like massless particles below the length scale 10^{-4} m and classical W fields and the exchange of W bosons might make possible charge entanglement. The hypothesis that Mersenne primes and Gaussian Mersennes correspond to a hierarchy of exotic weak physics leads to a highly unique vision for how life has evolved. In this model weak interactions play a key role in even macroscopic length scales.

2. Dark quark-antiquark pairs associated with the color bonds of the atomic nuclei could become charged via the emission of dark W boson and thus produce and exotic ion. The same can happen at the higher levels of dark matter hierarchy. This provides a non-local quantal mechanism inducing or changing electromagnetic polarization in turn inducing ordinary charge flows and thus making possible quantum control. Long range charge entanglement could be understood also in terms of classical W fields. Same applies to color entanglement which could be crucial element of topological quantum computation.

7.2.2 The Simplest Model For The Correspondence Between Generalized Josephson Frequencies And Cyclotron Frequencies

The vision is that generalized Josephson radiation is received resonantly at the magnetic flux tubes of the magnetic body and induces a phase transition like emission of cyclotron radiation

defining the response of the magnetic body communicated to DNA and possibly activating DNA expression and topological quantum computation like activities in DNA-membrane system [K2, K75]. A natural requirement is that membrane potential coding for the neural events and coded to generalized Josephson frequency is in turn coded to a position coordinate at flux tube by the resonance condition. The thickness and thus the local magnetic field at the flux tube must be varying in order that position coding is obtained.

Resonance condition equates generalized Josephson frequency with cyclotron frequency

The challenge is to understand the correspondence between Josephson and cyclotron frequencies and the what happens in the absorption of generalized Josephson radiation and how the response of magnetic body is generated. The following discussion represents a dramatic simplification of the earlier model.

1. The simplest coding would correlate $h_{eff}/h = n$ and the mass number A of ion: $n \propto A$ so that carrier frequency for Josephson radiation would correspond to cyclotron frequency. One could have $n = 2^k A$ and generalized Josephson frequency would correspond to cyclotron frequency through resonance condition at magnetic flux tube carrying particular ion and corresponding to a particular value of $h_{eff} \propto A$. Since Josephson contribution is small the two frequencies are near to each other with difference being of order 10 per cent.

2. The sub-band structure of EEG would naturally correlate with the cyclotron frequencies assignable to the biologically important ions. Bands with width about $\Delta f/f \sim .1$ would itself could correspond to the variation from the nominal value $B_{end} \simeq .2$ Gauss along flux tube. Proton would define the frequency scale with $f_c(p) = 300$ Hz and ion with charge Z and mass number A would have cyclotron frequency $f_c = Zf_c(p)/A$.

3. The atomic weight A has rather small number of values for biologically important ions if only bosonic ions are assumed (Bose-Einstein condensate). If also Cooper pairs are allowed, or if one accepts the suggestion of TGD inspired nuclear physics that exotic bosonic nuclei with mass of fermionic nuclei exist [L4], the situation changes. Many nucleon states in large h_{eff} phase can also allow pseudo Bose-Einstein condensates since anti-symmetrization in discrete degrees of freedom corresponding to sheets of multi-sheeted covering allows Bose-Einstein condensation like process in translational degrees of freedom. The anti-symmetrization gives also rise to negentropic entanglement [K61].

4. The magnetic field along flux tube could vary in range which is 10 percent of its mean value. The nominal values are $B_{end} = .2$ Gauss and its octaves. The variation along flux tube length would gives rise to a map of Josephson frequency - and thus membrane potential - to the flux tube coordinate. The variation of V would correspond to back and forth motion of "sensation" along the flux tube. Evoked potentials and neural noise would modulate the frequency and would be coded to this motion.

5. Resonance loop magnetic body-biological body requires that the motor response of the magnetic flux tube communicated to DNA has the same frequency spectrum as sensory input and thus correspond to a radiation at frequencies which correspond to differences of octaves of B_{end}. This can be achieved in several ways.

   (a) The change of B by octave at flux tube traversing cell membrane could be translated to phase transition changing the thickness of flux tube and thus the value of B. Generalized Josephson radiation could induce phase transitions reducing h_{eff} by a power of 2. If p-adic prime increases by the same power, do not change the length of flux tube but changes the value of B_{end} temporarily by flux conservation since the thickness of the flux tube changes. This would induce coherent emission of radiation at frequency very near to a multiple of cyclotron frequency and induce a response at DNA level if flux sheets traverse DNA strands. This response would induce genetic expression and possibly further transfer of cyclotron transition to Josephson junction so that a resonant feedback would result. Also topological quantum computation like activities might be induced.

(b) The magnetic field at the receiving portion of the magnetic flux tube receiving generalized Josephson radiation could have a value that corresponds to the difference of magnetic fields at the flux tube traversing cell membrane.

At the level of magnetic body the generalized Josephson radiation induces cyclotron phase transitions and in this manner communicate generalized sensory input to the magnetic body.

1. Chopin's piano pieces are highly emotional and half-jokingly one can ask whether tempo rubato due to the frequency modulation could code for the emotional content of the neural input. As a matter of fact, I have proposed that emotions correspond to the sensory experiences of the magnetic body. Frequency coding would provide the representation the information carried by nerve pulses and possible perturbations at cyclotron frequencies arriving from the magnetic body adding to the basic frequency.

2. The coherent photon state generated by J defines representation of evoked potentials V_1 as a generalized EEG interacting resonantly with magnetic body and providing feed back at harmonics of cyclotron frequency. This would create resonant feedback loops via DNA giving rise to biological representations as dark cyclotron photons interact with the living matter.

3. The scaling $h_{eff} \to n$ scales the time dependences of the Josephson current and Josephson radiation: $t \to t/n$. One obtains scaled variants of representations of the neural dynamics communicated to magnetic body. Different "stories" in various time scales is regarded as an essential element of intelligence and I have indeed proposed that they correspond to different values of h_{eff}. Different dark ions would correspond to these scaled variants of the representation.

To sum up, the model would realize the original idea about spectroscopy of consciousness rather concretely. The assumption that B_{end} has only the bands around preferred values differening by octaves is of course vulnerable to criticism. The model for hearing indeed suggests that instead of only octaves something analogous to music scale is needed. This well be discussed in more detail below. The role of fermionic ions remains open but there are slight indications that Na^+ might be importance for beta band.

Satellites

The input from cell membrane to the magnetic body can have two effects.

1. It can induce ordinary cyclotron transitions generating cyclotron radiation propagating from the magnetic body to genome to cell membrane as a small perturbation. This feedback could be called perturbative.

2. The input can also induce phase transitions by scaling the value of B_{end} by power of 2 (the simplest assumption) for the entire flux tube from the magnetic body to genome to cell membrane. This would give rise to a biological response as the ionic equilibrium concentrations change in accordance with the model based on "square root of thermodynamics" suggested by ZEO. Nerve pulse might be one such a response.

The perturbative feedback from the magnetic body to the DNA and from DNA to cell membrane would be present in two ways.

1. The feedback could affect the magnetic fields at flux tubes. Besides small oscillations also phase transitions This feedback could serve as basic control mechanism.

2. Feedback could affect also $V_1(t)$ besides the neural input such as evoked frequencies and give rise to additional frequencies satisfying the resonance condition. Nerve pulses generating motor actions could be one form of this feedback.

The general form of the perturbative feedback is easy to deduce.

1. Generalized Josephson current generating generalized Josephson radiation is trigonometric function of its argument of form $\int \omega(t)dt = \omega_0 t + \int \Delta\omega(t)dt$. $\Delta omega(t)$ contains a contribution coming from the modification of magnetic fields at both sides of the cell membrane and from $V_1(t)$.

2. If the amplitude of the feedback is small, it makes sense to develop the generalized Josephson current - essentially sine of its argument $\int \omega_0 t + \int \Delta\omega(t)dt$ - by using trigonometric formulas first and then expressing the trigonometric functions of $\int \Delta\omega(t)dt$ as Taylor series.

3. If $\Delta\omega(t)$ is superposition of trigonometric functions, this gives rise to series of higher harmonics involving integer combinations of generalized Josephson frequencies associated with various charged particles.

4. The simplest - perhaps un-necessary restrictive - possibility is that the feedback uses same frequencies as sensory input to magnetic flux tubes: this poses conditions on the allowed phase transitions inducing a change of B at the magnetic body. In this case only linear combinations of the basic frequencies ω_i with integer coefficients appear.

5. A sinusoidally varying perturbation would contribute to the generalized Josephson radiation frequencies of form

$$\sum_i n_i f_i \ ,$$

   and give rise to what might be called satellites in EEG. These can contribute to conscious experience at magnetic body if the linear combination of the frequencies is cyclotron frequency. For instance, 5 Hz theta frequency could result as $f_c(Ca^{++}) - f_c(Co^{2+})$.

6. Simplest satellites are of form $f_i \pm f_j$ and thus appear as mirror pairs. In 10 per cent accuracy these frequencies are cyclotron frequencies and the first guess is that only bosonic ions contribute. The existence of the mirror satellites might be regarded as a killer prediction.

Amazingly, narrow EEG bands which are mirror images of each other with respect to alpha band have been reported [**?**]. Besides alpha band at 11 Hz, Nunez mentions also narrow sub-bands at 3, 5 and 7 Hz at delta and theta range, as well as the bands at 13, 15 and 17 Hz in beta band [**?**]. All these frequencies are expressible in the form $f_c \pm f$, $f = 5$ Hz. $f = 5$ Hz would correspond to cyclotron frequency in alpha band during first stage sleep if the transition $B_{end} \to B_{end}/2$ occurs during this stage of sleep. Of course, several octavess of B_{end} are in principle possible during wake-up state too.

The cyclotron frequencies associated with the bands are 8, 10, and 12 Hz. The cyclotron frequencies of bosonic ions $^{80}Se^{2-}$, $^{64}Zn^{2+}$, and $^{55}Mn^{2+}$ for a magnetic field strength $B_{end} = .2$ Gauss are 8.00, 9.90, and 12.00 Hz. The cyclotron frequencies of bosonic ions $^{59}Co^{2+}$ and $^{56}Fe^{2+}$ would be 10.52 Hz and 11.36 Hz and the satellites are at frequencies 5.52 Hz and 6.36 Hz and 15.52 and 16.36 Hz. All these frequencies belong to the bands reported by Nunez since their widths are 1-2 Hz. Thus the frequencies of all bosonic ions in alpha band and in their satellites belong to the bands reported by Nunez for values of f_J and B_{end} very near to their nominal values used in calculations!

With these assumptions the frequencies $3f_c(Mn^{2+}) \pm f_J$ are 40.97 Hz and 30.97 Hz corresponding to 40 Hz band and the threshold of gamma band. That $f_c(O^{2-}) = 39.6$ Hz is also in this band suggests additional reason for why oxygen is so important for consciousness. $f_c(Mg^{2+}) = 26.3$ Hz is very near to Schumann resonance 26 Hz and its upper satellite corresponds to the threshold of gamma band.

What is also very remarkable that the 10 Hz magic frequency of the memetic code corresponding to the secondary p-adic length scale $L(2, 127)$ associated with Mersenne prime M_{127} characterizing electron and emerging as the basic prediction of the zero energy ontology appears. It should be also noticed that $f_J = 5$ Hz frequency corresponds to cognitive theta appearing during tasks requiring mathematical skills. Note that the scaling of ordinary value of h_{eff} by a factor of 2 scales 10 Hz frequency to 5 Hz.

Harmonics

As a special case about satellites one obtains harmonics $f = nf_i$ and these can induce both ordinary cyclotron transitions.

1. For alpha band the third harmonics of most bosonic ions are in the range 28.2-34.2 Hz and roughly in gamma band above 30 Hz assignable with the control of cognitive activities from a flux quantum of Earth's magnetic field.

2. Fifth harmonics of alpha band would are in the range 37.5-57 Hz. The fermionic ion Na^+ would correspond to 65 Hz. During REM sleep EEG very similar to awake but 65 Hz resonance is present. One can ask whether fifth harmonics are present during REM sleep and serve as correlates for conscious visual imagery.

3. The fourth harmonic of 40 Hz thalamo-cortical resonance band is very important EEG band. The upper satellite of the third harmonic of Mn^{2+} is 37.9 Hz. The third harmonics of fermionic ions $^7Li^+$ and Na^+ correspond to 42.9 Hz and 39 Hz (Schumann resonance) respectively.

   As will be discussed, a more natural interpretation for thalamo-cortical resonance frequency and also the observed 20 Hz and 80 Hz resonance frequencies is in terms of p-adically scaled values of both h_{eff} and B_{end}.

7.2.3 Music Metaphor

I have proposed music metaphor as a useful heuristic guideline in attempts to understand brain functioning and music metaphor can be also used in attempts to understand EEG.

Right brain sings, left brain talks

I have proposed that right brain sings and left brain talks metaphor could apply quite generally to the frequency modulated communications to the magnetic body. That it could distinguish between hemispheres is also an interesting hypothesis to study.

1. Right brain sings

Right brain sings would in the first approximation (forgetting glissandos!) mean that Josephson frequency and thus membrane potential is a piecewise constant function of time.

"Singing" would represent a special case of frequency modulation for Josephson radiation and would require that various perturbations from neural activity and from feedback from magnetic body are small corrections possibly contributing to the emotional content of the signal (vibrato).

2. The metaphor would suggest that generalized Josephson frequencies have a set of discrete values analogous to the notes of the music scale which naturally spans one octave. This would reflect in the spectrum of bio-photons.

3. The variation range for the resting potential V is not a full octave so that the model involving only resting potential does not allow to realize the scale. The addition of the dominating cyclotron contribution saves the situation, and - just as in the case of hearing [K78] - the realization of scale in terms of the values of B_{end} becomes possible.

4. The resonance condition for cell membrane-magnetic body system requires that B_{end} has a spectrum of discrete values analogous to notes of the scale. If one takes 10 percent rule seriously and requires that the "note bands" do not overlap, one obtains $f_{n+1} = f_n + k_f n$, $k = .1$, giving $f_n = (1+k)^{n-1} f_0$. $f_{n_{max}}/f_0 = 2$ gives that the number of "notes" is 7.3 suggesting that 8-note scale could relate directly to the spectrum of generalized cyclotron frequencies.

5. If this picture is correct, the existence of minor and major scales means that emotional content of major and minor scales could reduce to that for the membrane potential scales so that the spectrum of B_{end} would code for the emotional content of the scale.

2. Left brain talks

Left brain talks metaphor suggests that there is in some sense discrete carrier frequency which is frequency modulated in such a manner that the outcome is analogs for the phonemes of language.

1. Binary code for phonemes is suggestive and I have considered the possibility that genetic code might define the six bits of code words represented as phonemes with duration of about.1 seconds corresponding to the fundamental time scale identifiable as secondary p-adic time scale of electron in zero energy ontology. The occurrence/non-occurrence of nerve pulse having duration somewhat longer than millisecond is an obvious candidate for defining the values of the bit.

2. The coding of nerve pulse patterns to cyclotron frequencies suggest that the carrier frequency f_J is higher than kHz. This requires reduction of h_{eff} by a suitable power 2^{-k} and scaling of B_{end} by 2^k. Also flux tubes contain cyclotron condensate of electric Cooper pairs with cyclotron frequency of order 5.6×10^5 Hz suggest themselves.

   "No nerve pulse" situation would correspond to a situation in which generalized Josephson radiation with frequency f is generated and magnetic flux tube detects it: continual "beee...p" would characterize the "sensation" at the flux tube would definite bit "0". As the nerve pulse passes by the frequency of beep changes about.1 for a time of order millisecond and returns to a value differing slightly from the original value due to hyperpolarization increasing the value of the resting potential. Thus bit "1" would have just the obvious representation.

4. This form of proposal does not assume any time discretization as the earlier proposals and the code would thus be very flexible. The duration of phoneme would be however about.1 seconds. The capacity to code six bits would require allow 1.5 ms minimal duration for nerve pulse. If the duration of "beep" does not matter at all then only the number of pulses during.1 second interval matters, and one obtains the familiar rate coding and 6 bit reduce to 7 possible values for the number of nerve pulses. This cannot represent all phonemes of spoken language.

   The situation changes if there is background oscillation of the f with period of order nerve pulse duration of order.1/64 seconds $\simeq$ 1.6 ms. In this case it is possible to tell whether given period contains beep or nerve pulse. This would give rise to 6 binary digits able to code for 64 analogs of phonemes and one can consider also the analog of genetic code giving rise to redundancy. This kind of redundancy might be necessary since it can happe that given nerve pulse is present during two subsequent periods.

If this picture is on correct track, language would appear already at the level of communications to magnetic body and spoken and written languages would represent only its "externalizations". The first basic difference between speech and singing (and left and right brain) could be due to the fact that speech uses electronic Cooper pair condensates whereas singing uses ionic B-E condensates. Speech would also involve nerve pulse time scale in an essential manner an carry information about phase transitions changing the value of B_{end}.

Could the analogs of music scales appear in the communications to the magnetic body

The basic questions concern the allowed values of magnetic field B_{end} and the values of membrane voltage defining the scale of generalized Josephson frequencies.

Consider first hints concerning the spectrum of B_{end}.

1. Position coding suggests a band of about $\Delta B_{end}/B_{end} \simeq 10$ percent related to the position coding. This range would correspond to the frequency variation coming from the additive contributions to the resting potential from neural activity and magnetic body.

2. The model for the various stages of sleep relying on p-adic length scale hypothesis suggest that the scale of B_{end} comes as at least three powers 2^{-k}, $k = 1, 2, 3$ corresponding to alpha, theta, and delta bands. $h_{eff}/h = 2^k n$ would come as three powers in the same manner. It is also known that the frequencies 20, 40, and 80 Hz are resonance frequencies of EEG. 80 Hz is also resonance frequency in ERG.

3. This suggests that at least 6 octaves are involved. The next two powers of two correspond to 160 Hz and 320 Hz quite near to proton's cyclotron frequency 300 Hz for the nominal value of B_{end}.

These observations suggest that music metaphor is realized in rather concrete form. EEG would decompose to octaves just as music scale does. Each ion would define with its own scale scale and thus serve as an analog of instrument (note that the energy spectra of dark photons could be nearly identical for ions) corresponding a spectrum of values of B_{end}. The fundamental octave would correspond to scale with fundamental defined by $B_{end} = .2$ Gauss. In particular, 10-20 Hz interval would be associated with alpha band as the basic octave.

The attempt to identify different notes of the scale in terms of different bosonic ions does not look like an attractive idea. The region 10-20 Hz contains only 4 bosonic cyclotron frequencies: that of corresponding to Co, Fe, Mn in alpha band and Ca at 15 Hz and they need not correspond to notes of the same scale but fundamental frequencies of different keys. EEG could represents same piece in different keys labelled by bosonic ions. If this is the case, one could disentangle information from EEG by separating these contributions from each other by using the fact that they correspond to same function of time but with differently scaled argument.

7.2.4 An Attempt To Understand EEG In Terms Of The Resonance Model

In the following an attempt to understand the basic structure of EEG (`http://tinyurl.com/2mapqg`) and its relationship to state of consciousness is made.

Basic tests

The identification of EEG bands in terms of cyclotron frequencies identified as generalized Josephson frequencies is quite powerful prediction and deserves sensibility check.

1. The value of the endogenous magnetic field is $B_{end} = .2$ Gauss is 2/5: th of the nominal value of the Earth's magnetic field. B_{end} could be assigned to the magnetic field at flux tubes going through cell membrane (note however that also other values perhaps realizing the analogy of music scale with octaves is suggested by above considerations). The value of B at magnetic body, whose flux tubes would presumably be transversal to those connecting cell DNA and cell membrane, would be slightly different since Josephson frequency does not contribute to cyclotron frequency and have relative variation $\Delta B/B \simeq .1$.

   (a) If the variation $\Delta B/B$ corresponds to the variation of the Earth's magnetic field B_E scaling roughly like $(R_E/r)^3$ with the distance from the Earth's center, one would have $\Delta R/R_E \simeq .033$. This corresponds to $\Delta R \simeq 210.5$ km. Note that the F-layer of ionosphere - its densest layer - begins at about 200 km.

   (b) It could also be that B corresponds to the magnetic field of Earth. For Earth's magnetic field the distance at which its magnitude is about $2/5B_E$, $B_E = .5$ Gauss, would be roughly $r = 1.4R_E$. B_E defines the cyclotron frequencies of various ions and resonance condition must hold true for the resonant absorption of generalized Josephson radiation. The value of B_E should vary in some limits at flux tubes in order to achieve coding of generalized Josephson frequency by distance along flux tube: this gives rise to the EEG band.

2. If one assumes that only bosonic ions are relevant then for $B_{end} = .2$ Gauss, the values of relevant ionic cyclotron frequencies would be $f_c/Hz \in \{50, 27.4, 37.4, 25.0, 15.0, 11.4, 10.8, 9.5, 7.6\}$ Hz corresponding to ${}^6Li^+, Mg^{++}, Ca^{++}, Mn^{2+}, Fe^{2+}, Co^{2+}, Xn^{2+}, Se2-$ and 37.4 Hz near 40 Hz thalamo-cortical resonance frequency for molecular ion O^{2-} related to the bio-photon emissions in turn having interpretation as transformation of dark EEG photons to ordinary ones [L11]. There are three cyclotron frequencies in alpha band which makes it rather special.

3. The model could explain why wake-up consciousness is effectively lost when EEG frequencies are below 7.6 Hz: there would be no cyclotron condensates receiving input as generalized Josephson radiation and no consciousness assignable to the magnetic body.

   An alternative possibility is that consciousness changes its character during sleep. If magnetic flux tubes with B_{end} scaled down most naturally by factor 1/2 or 1/4 suggested earlier to explain the stages of sleep and h_{eff} is scaled up by factor 2 or 4 respectively, cyclotron frequencies are reduced by factor 1/2 or 1/4, and can be low enough for cyclotron resonance conditions to be satisfied. This scales various frequency bands down by factor 1/2 or 1/4. This consciousness would differ from wake-up consciousness, and this might explain why we do not have memories about sleeping period and conclude that sleeping period is non-conscious.

   If B correspond to the Earth's magnetic field at large enough distance so that the distance of the receiving flux tubes would increase roughly by a factor $2^{k/3}$, $k = 1, 2$, for theta and delta bands. The value of B_{end} could also change in a phase transition increasing p-adic prime approximately by a factor 2^k. This phase transition is proposed to be fundamental for metabolism [K75].

Theta and delta bands

Wikipedia article about EEG (`http://tinyurl.com/2mapqg`) summarizes the basic features of EEG bands.

1. Delta band is below 4 Hz and appears frontally in adults and posteriorly in children with high amplitude waves. It appears during adult slow wave sleep, in babies and during continuous attention tasks.

   Cyclotron frequency hypothesis and $h_{eff} \to 4h_{eff}$ hypothesis are consistent with these features. In particular, the model of slow wave sleep conforms with this picture. The satellite associated with Schumann resonance would be in alpha band and an interesting question is whether it appears in EEG during slow wave sleep.

2. Theta waves (4-7 Hz) appear in locations not related to task at hand, is higher in young children, correlates with drowsiness in adults and teens, is associated with "idling", and with inhibition of elicited responses.

   These features conform with the cyclotron frequency hypothesis and $h_{eff} \to 2h_{eff}$ hypothesis scaling alpha band to theta band corresponding to idling and also with the explanation of sensorimotor band 12-16 Hz in terms of satellites produced by input from magnetic body parts corresponding to alpha band. Also sleeping spindles can be understood. There would be no cyclotron frequency response at magnetic flux tubes responsible for wake-up sensory consciousness and motor activity. The performance of tasks would induce the transition $h_{eff} \to h_{eff}/2$ activating alpha band.

Alpha and Mu bands

Mu band is associated with sensorimotor motor cortex and is identified frequency range $8 - 12$ Hz and can be associated with rest-state motor neurons. Often one calls this band also alpha band.

Wikipedia definition identifies alpha band as $8-15$ Hz range. alpha band appears in posterior regions of at both sides and has higher amplitude on non-dominant sides. In a relaxed state beta band disappears and the spectral power in alpha band increases. alpha dominance correlates with relaxed/reflecting state of consciousness, appears when eyes are closed, and is also associated with inhibition control, seemingly with the purpose of timing inhibitory activity in different locations across the brain. alpha band appears also in coma.

A possible identification for Mu band is in terms of sub-bands associated with $f_J = f_c$ where f_c is cyclotron frequency for bosonic ions Se^{-2} (7.6 Hz), Zn^{2+} (9.4 Hz), Co^{2+} (10 Hz), Fe^{2+} (10.8 Hz), and Mn^{2+} (11.4 Hz). Depending on definition of alpha band it includes also Ca^{2+} (15 Hz). Also the sensorimotor rhythms belong to this band but in TGD framework it can be distinguished from genuine alpha band.

In a relaxed state beta band disappears and the spectral power in alpha band increases. The simplest explanation is that the value of h_{eff} corresponds to alpha band. An interesting

question is whether the 10 Hz resonance frequency associated with the excitations of electric field in ionospheric cavity behaving like 2-dimensional waves on sphere is involved. Also the 10 Hz frequency assignable to electron's CD could be involved.

Sensorimotor rhythms in range 12-16 Hz

Sensorimotor rhythm corresponds the range 12-16 Hz and associated with physical stillness and body presence is a challenge for the model. For bosonic ions (Mn^{2+} and Ca^{2+} only the cyclotron frequencies 11.4 Hz and 15 Hz belong to this band. These are not enough if one is ready to losen the hypothesis $\Delta f_c/f_c \simeq 10$ per cent.

Two basis options can be considered.

1. If B_{end} indeed has spectrum of values analogous to music scale one could explain sensory motor rhythms in terms this spectrum for some ion. alpha band extended to a scale is the simplest possibility. The notes C, E_b, E, F G A_b, and A would correspond to $f/Hz \in \{10, 11.8, 12.6, 13.3, 14.9, 15.8, 16.8\}$. D would correspond 1.12 Hz still in alpha band.

2. The increase of h_{eff} by factor of two and satellite phenomenon provide an alternative identification of beta band. alpha band would be scaled down to about 5 Hz and would be fed by cyclotron frequencies in alpha band from magnetic body. Stillness would mean that order sensory input to the part of the magnetic body responsible for wake-up consciousness is absent since since 5 Hz does not correspond to any cyclotron frequency for the nominal value of B_{end}. The satellite frequencies for alpha band would be in the range 12.6-16.4 Hz. So called sleeping spindle during first stage of sleep for which also TGD model increase of h_{eff} by a factor of two, are also in this range. The interpretation would be as cyclotron communications from alpha part of magnetic body received by scaled down alpha part of neuronal membranes.

Beta band

beta band ranges from 16 to 31 Hz, appears in both sides, has symmetrical distribution, is most evident frontally, and waves have low amplitude. beta band is associated with active, busy or anxious thinking and active concentration and is chaotic and highly asynchronous.

Again one can consider several explanations.

1. The simplest explanation of beta band is in terms of octave wide scale associated with Ca^{++} ion with $f_c = 15$ Hz for $B_{end} = .2$ Gauss.

2. Second possibility is beta band involves in an essential manner the feedback from magnetic body and satellite frequencies which however need not induce cyclotron transitions unless one is willing to losen the basic criterion. If higher order effect is in question, the low beta amplitudes can be understood. Harmonics induce cyclotron transitions without further assumptions and one obtains a rich spectrum of sub-bands.

Besdes Ca^{++} octave beta band can contain resonances.

1. Mg^{++} is the only bosonic ion having cyclotron frequency in beta range at $f_c(Mg^{++}) = 25$ Hz and could appear as resonance frequency in beta band. Alternatively it could correspond fundamental frequency assignable to gamma band.

2. If one accepts the hypothesis about octaves of B_{end} then gamma band should contain also resonance frequencies around 15.2 Hz, 20 Hz and 30 Hz corresponding to Se^{2+}, alpha band and Ca^{2+}. The resonance at 20 Hz is known to exist.

3. As already noticed, in slow wave sleep Schumann resonance at $f_S = 27.3$ Hz could generate this frequency by satellite mechanism but the amplitude would be smaller than for direct generation. Also 10 Hz alpha frequency and Ca^{2+} frequency can add up via satellite mechanism rise to $f_c(Mg^{++}) = 25$ Hz.

Gamma band

Gamma band is associated with somatosensory cortex and displays during cross-modal sensory processing and also during short memory matching of recognized objects, sounds or tactile sensations. Clearly gamma band relates associative regions of cortex. Thalamo-cortical resonance frequency with nominal value of 40 Hz belongs to gamma band.

The simplest option is that gamma band contaings several octave scales associated with $f_c(Mg^{++}) = 25$ Hz, $f_c(O^{2-}) = 37.4$ Hz and $f_c(6Li^{+}) = 50.1$. One can criticize this assumption: 25 Hz is roughly 15 per cent lower than 31 Hz. One the other hand, the identification of the various frequency is far from unique.

Ten percent rule for $\Delta f/f$ suggests that thalamo-cortical resonance of 40 Hz could correspond to 37.4 Hz. This would predict a large amplitude in accordance with resonance interpretation. Note that fourth harmonics of alpha frequencies are around the thalamo-cortical resonance frequency.

An alternative explanation of 40 Hz resonance is that it corresponds to the p-adic scaling of h_{eff} and B_{end}. Ca^{2+} would give rise to 60 Hz resonance frequency and also other bosonic ions would give rise to resonances in gamma band. The octave of $f_J(Mg^{2+})$ would give 50 Hz resonance in gamma band.

The strong amplitude of the feedback contribution in the argument of generalized Josephson current $J = J_0 sin(\omega_0 t + X)$ also means that the higher terms in Taylor expansion with respect to X are important and large number of satellites $\omega_0 + nf_c)$ is important so that the amplitude becomes chaotic. The harmonics of bosonic cyclotron frequencies predict quite rich spectrum of sub-bands in beta and gamma banda and it would be highly interesting to test the prediction.

To sum up, according to the proposed picture the basic contribution to alpha, beta, and gamma bands correspond to octave scales associated with bosonic ions in alpha band around 10 Hz, Ca^{++} around 15 Hz, and Mg^{++} around 25 Hz. There are also resonance contributions and contributions from the octaves of the fundamental octaves. Besides the proposed picture many other options can be imagined. One must make working hypothesis and the basic challenge is to avoid too strong assumptions.

7.2.5 EEGDuring Sleep

The EEG during sleep [**?**, J2] provides a testing ground for the proposed anatomy of EEG. Sleep consists of 90 + 90 minute periods of NREM and REM sleep. This period is also the period of brain hemisphere dominances during wake up and day dreaming occurs with the same period as REM sleep. During REM sleep the EEG is essentially similar to that during wake-up. These observations inspire the hunch that brain hemisphere dominance dictates whether REM or NREM is in question.

The scalings of h_{eff} by factor 2 and 4 accompanied by corresponding compensating scalings of B_{end} so that generalized Josephson energies are almost invariant seem to explain the basic characteristics of these states but it is not completely clear whether the phase transitions occur for both cell membrane space-time sheets and flux quanta or only for the first ones.

EEG during stage 1

The stage 1 sleep is between wake-up state and full sleep involving sometimes hypnagogic hallucinations. During stage 1 of deep sleep [**?**] theta waves in frequency range 4-8 Hz beging to dominate and amplitudes increase as frequency is reduced. The transitiosn $h_{eff} \to 2h_{eff}$ and $B_{end} \to B_{end}/2$ should take place and would take place also in relaxed state and generates sensorimotor rhythms.

1. If $h_{eff} \to 2h_{eff}$ transition takes place alpha band is scaled down to the range 3.8-5.7 Hz. Ca^{++} frequency scales down to 7.5 Hz so that one indeed obtains theta band. The amplitudes associated with these frequencies are expected to be high. These amplitudes should dominate and EEG should look rhythmic rather than chaotic as indeed observed. The amplitudes behave as $1/f_c$ and thus increase with decreasing f_c. The fact that the amplitudes increase with decreasing EEG frequency suggests that the frequencies they correspond to different cyclotron frequencies.

2. The secondary amplitudes generated by satellite mechanism for alpha band give rise to sensorimotor rhythms appearing also in sleeping spindles. The mirror frequencies are in theta band below 5 Hz.

The most important range 7.5-15 Hz of cyclotron frequencies would be scaled down to 3.75-7.5 Hz which indeed corresponds to the theta band. If one excludes Ca^{2+}, the range for bosonic ion reduces from $7.5-11.4$ to $3.75-5.7$ Hz. The satellites correspond to the range $.05-8.7$ Hz and $7.45-9.4$ Hz plus Ca^{2+} satellites at 3.8 Hz and 11.2 Hz. With Ca^{2+} forming a possible exception, the resulting frequency ranges are consistent with empirical facts. Of course, it is quite possible that magnetic body does not generate cyclotron transitions at Ca^{++} cyclotron frequency.

One must consider two options.

1. If both cyclotron frequencies at magnetic body and generalized Josephson frequencies are scaled down, the communication-control loop between magnetic and biological body remains intact. This might be necessary for the survival. This raises the question whether sleep actually means a loss of consciousness. Could it be that only the character of consciousness is changed? Since the magnetic body moves to a different page of the "Big Book" having as pages various singular coverings of the embedding space, one could argue that consciousness is not lost but that it is difficult to remember anything about this period during wake-up period since the negative energy signals responsible for memory recall should leak to another page of Big Book and this process could take place with a low rate. The mental images appearing just at the border of falling asleep could give a glimpse about the character of conscious experience in this.

2. The phase transition changing Planck constant could take place for cell membrane space-time sheets only so that only generalized Josephson frequencies would be scaled down. For flux sheets traversing through DNA the value of Planck constant would not be changed. In this case resonance conditions satisfied in wake-up state would be satisfied for the even harmonics of Josephson frequencies during stage 1 of sleep. Therefore the sensory-motor loop involving magnetic body would not be so active in the relaxed state and in the first stage of sleep.

EEG during stage 2

The appearance of sleep spindles distinguishes stage 2 from stage 1. Sleeping spindles are sudden increases in EEG amplitude and frequency from theta band to 12-16 Hz [**?**]. The spindles last .5-.1.5 seconds and appear with a period of about minute. In some sources frequency range 7-16 Hz is given as sleeping spindle range. The so called K-complexes are sudden increases in EEG amplitude but no change in frequency.

The natural interpretation of sleep spindles is in terms of input from magnetic body in alpha band which generates by satellite mechanism sensorimotor rhythms assignable to a relaxed state. Sleep spindles would thus correspond to the satellites of alpha band identifiable as responses of the corresponding Josephson junctions to occasional strong control signals at cyclotron frequencies in alpha band. K complexes could be interpreted as signals from magnetic body but inducing no response. It might be that these sudden responses reflect the fact that the left brain is not fully asleep yet.

EEG during stages 3 and 4

Most of EEG power during deep sleep stages 3 and 4 is in the range .75-4.5 Hz [**?**]. The most straightforward interpretation is in terms of the scaling $\hbar \to 4\hbar$ so that alpha band would correspond to 2.5 Hz and beta frequency 15 Hz to 3.75 Hz.

Again one has two options corresponding to the scaling of $\hbar$ for all flux quanta and only for the cell membrane space-time sheets.

1. For the first option consciousness need not be lost during these phases of sleep if the above argument makes sense. The experiences just at the border of wake-up could give an idea about what this kind of consciousness is.

2. For the second option DNA cyclotron transitions could be important during deep sleep and it might be even possible to speak about DNA consciousness. For phosphorylated DNA sequences with charge of 2 units per single base-pair one would have $A \geq 300$. More precisely, the atomic weights for base pairs plus phosphate group and deoxyribose sugar are $327, 321, 291, 344$ corresponding to A, T, C, G. From the fact that proton's cyclotron frequency for $B_{end} = .2$ Gauss is 300 Hz one obtains that DNA cyclotron frequency is 1 Hz in good approximation. This would suggest that during deep sleep DNA cyclotron transitions are induced by Josephson frequencies and that DNA defines the sensory perceiver.

7.2.6 Schumann Resonance And Consciousness

The lowest Schumann resonance frequency $f_S = 7.8$ Hz is conjectured to be important for consciousness.

1. One might imagine that the magnetic body of Earth as a conscious entity communicates to and controls brain using Schumann resonance. A possible mechanism is communication of Schumann radiation to DNA where it arrives along magnetic flux tubes to cell membrane as external perturbation superposing to membrane voltage as sinusoidal perturbation in the first approximation. One can decompose Josephson current as

$$J = J_0 sin(\omega_J t + X) = J_0[sin(\omega_J t)cos(X) + cos(\omega_J t)sin(X)] \ , \ X = \omega_0 t + \frac{Ze}{\hbar_{eff}} \int V dt \ ,$$

   and expand $sin(X)$, and $cos(X)$ in powers series of X. If X is sinusoidal, a perturbation with frequency f the series gives rise to the spectrum $f = f_0 + nf$ which should be equal to f_c for some ion at magnetic body. In the case of Schumann frequency this would give lowest frequency $f_0 \pm f_S$. If there is cyclotron frequency satisfying the resonance condition $f_c = f_0 + f_S$, Schumann frequency is perceived at magnetic body.

2. If sleep means formation of a kind of collective consciousness, then one expects that during first and second state of sleep when the scale f_J is reduced by $1/2$ *resp.* $1/4$ the resulting frequency might correspond to cyclotron frequency. During second state of sleep alpha band is shifted to 2.5 Hz and $f_J + f_S = 10.3$ Hz is in alpha band so that Schumann resonance could contribute to alpha consciousness. For the first phase of sleep alpha band is at 5 Hz (theta band) and for $f_J = 10$ Hz one has $f_J + f_S = 12.8$ Hz in beta band - this is near to the scaled down cyclotron frequency of $f_c(Mg^{2+}) = 12.5$ Hz.

What about the interaction of higher Schumann resonances with consciousness? Schumann resonances are around 7.8, 14.3, 20.8, 27.3 and 33.8 Hz and could give rise to satellites, which for $f_J = 2.5$ Hz correspond to cyclotron frequencies. $f_c(Mg^{2+}) = 25.0$ Hz is not too far from $f_S = 27.3$ Hz Schumann resonance. During slow wave sleep the satellite $f_S - f_J = 27.3 - 2.5$ Hz equal to 24.8 Hz. For $f_S = 14.3$ Hz the satellite would be 11.8 Hz rather near $f_c(Mn^{2+}) = 11.4$ Hz.

7.2.7 What About Proton And Electron?

The model discussed has not said anything about proton and electron. with cyclotron frequencies of 300 Hz and 5.6×10^5 Hz for $B_{end} = .2$ Gauss. There are two hints about the role of these frequencies.

1. The spectrum of audible frequencies spans 10 octaves extending from 20 Hz to about 2×10^4 Hz. For bats the spectrum extends to MHz region. The frequency modulation of EEG frequencies by frequencies above 100 Hz produces a vanishing average effect analogous to small ripples much smaller than the wave-length of wave in water.

2. The durations associated with the nerve pulses are few milliseconds.

A natural manner to represent auditory information would be by using electron's cyclotron frequency as a carrier frequency. The proton cyclotron time 3.3 ms could be short enough to allow a representation of nerve pulse patterns as frequency modulation. This would require $f_J = f_c(p) =$ 300 Hz for the neuronal membranes involved. Also electronic cyclotron frequency would allow the representation of neuronal events as slow frequency modulations. The effects of VLF radiation at these cyclotron frequencies on living matter could serve as a test for this proposal.

7.3 The Effects Of ELFFields On Brain And High T_c Ionic Super Conductivity

The article "Spin the tale on the dragon" by David Jarron [**?**] gives excellent popular review about the history of the bio-electromagnetic research and about the frequencies for which electromagnetic fields have special effects on living matter and brain. The material from this article led to the realization of how brain manages to be a macroscopic quantum system in TGD Universe. A more technical view about the effects can be found from review articles of Adey and Blackman [**?**]. The online review article of Cherry [**?**] provides a good technical representation about various effects of weak ELF em fields and ELF modulated radiofrequency em fields on brain and an extensive list of references.

7.3.1 Summary About Effects Of ELF EM Fields On Brain

The work by pioneers of bio-electromagnetism (Wertheimer, Milham, Marino, Becker, Adey, Blackman and many others) which began already at sixties led to amazing discoveries about ELF fields on brain. The article of Blackman [**?**] provides a detailed summary of these developments. The results of the work of Bawin, Adey, Blackman and others can be summarized by saying that radio frequency em fields amplitude modulated by ELF frequencies affect in certain frequency and amplitude windows brain tissue [**?**, **?**, **?**]. The function of the radio frequency carrier wave is to facilitate the penetration of em field into tissue and its frequency is not essential for the occurrence of the effect. Presumably nonlinear effects give rise to a secondary wave with modulation frequency which is the primary source of effects.

Basic effects

The effects of ELF em fields on brain include chemical, physiological and behavioral changes within windows in frequency and field intensity. It is essential that the effects have been observed only in vertebrates which thus possess EEG. A good summary is the online review article of Cherry [**?**].

The well documented and established non-thermal biological effects of EMR include significant alteration of cellular calcium ion homeostasis, reduction of melatonin, and the detection of Schumann Resonances by human and avian brains. A key effect is change in Ca^{2+} homeostasis: Ca^{2+} it is involved with both pre- and postsynaptic steps of nerve pulse transmission and also with intracellular communication. For instance, Ca^{2+} is involved with gene expression, the development and plasticity of nervous system, modulation of synaptic strengths, and with $Ca^{2+} - c$AMP signal transduction process.

Change in Ca^{2+} homeostasis has harmful effects in central nervous system, endocrine system and immune system. At the level of CNS this means changes of reaction time and behavioral alterations. At the level of neuro-endocrine system a good example is the reduction of the melatonin production in pineal gland having wide variety of harmful effects since melatonin serves as effective scavenger of free radicals: among the effects are DNA strand breakage, chromosome aberrations and problems with gap junction communications. Melatonin is also crucial for healthy sleep and for the reduction of cholesterol and blood pressure. In the case of immune system an example is provided by the change of functioning of lymphocytes in turn reducing the competence of immune system making the subject more vulnerable to allergens, toxins and viruses.

Amplitude windows

There are several amplitude windows but here only the main amplitude windows will be discussed. For the first window ELF em fields have values of electric field in tissue around 10^{-7} V/m. The effects are high level effects and associated with navigation and prey detection in marine vertebrates and with the control of human biological rhythms. For ELF modulated radio frequency fields (RF) and microwaves (MW) the intensities are around $1 - 10$ V/m. In this case the effects are neurophysiological effects are lower level effects at the level of the brain tissue. In the case of brain tissue maximal sensitivity to electromagnetic fields occurs between 6 and 20 Hz.

In order to get grasp about orders of magnitude, it is good to notice that on some experiments cell membrane electric field has a strength about 10^7 V/m whereas EEG electric fields in the range $5 - 10$ V/m. The fact that the second intensity window corresponds to $1 - 10$ V/m suggests that the em field simulates the em field associated with EEG: a valuable guideline in attempts to understand what is involved. For Schumann resonances electric field is of order .6 mV/m. For sferics (em perturbations associated with lightnings) magnetic field strength is not above nTesla: this corresponds to electric field strength 10 V/m associated also with EEG waves [F6]. Field strength of V/m corresponds roughly to energy flux $\mu W/m^2$.

The presence of windows and weak intensities implies that the effects cannot be thermal. A good metaphor is the effect of radio noise on radio receiver: it occurs at definite frequency and destroys the information content of the original transmission.

The effects occur at harmonics of cyclotron resonance frequencies

Blackman also discovered that odd multiples 15, 45, 75, 105... of 15 Hz had much stronger effect on tissue than even multiples 30, 60, 90... Hz and realized a possible role of Earth's magnetic field [**?**]: it must be however emphasized that the value of magnetic field in question is $B_{end} = .2$ Gauss and smaller than $B_E = .5$ Gauss. A possible interpretation is that harmonics of cyclotron frequencies might be the information carrying frequencies in EEG.

In response to the results and speculations of Blackman, Liboff formulated ionic cyclotron resonance (ICR) model [**?**] based on the realization that the frequencies in question correspond to multiples of the cyclotron frequencies of Ca^{2+} ion in a magnetic field $B_{end} = .2$ Gauss. This model was classical. Later Blanchard and Blackman proposed so called ionic parametric resonance model (IPR) [**?**]. This phenomenological model combines ICR model with ideas about atomic physics. There are several objections against ICR model; classical orbits of ions in Earth's magnetic field have radius of order meters; dissipative effects and Brownian forces do not allow cyclotron orbits; charge-to mass ratios appearing in cyclotron frequencies correspond to vacuum rather than water environment characterized by a large value of dielectric constant; it is difficult to understand why odd multiples of cyclotron frequencies give rise to stronger effects [**?**]. Some of these objections apply also to IPR model.

The pattern of data seems to suggest that the interaction occurs at quantum level. This is in dramatic conflict with the predictions of the standard quantum theory and with the standard view about space-time.

Are quantal effects in question?

The conclusion that the effect of ELF fields on brain represents quantum effects associated with the transitions of ions confined in magnetic field having same strength as Earth's magnetic field, is supported by the following observations.

1. The frequencies $15, 30, 45, 60, 75$ Hz having effect on primates are multiples of the same basic frequency $f = 15$ Hz, which turns out to be the cyclotron frequency of Ca^{2+} ion in magnetic field $B_{end} = .2$ Gauss. That these frequencies come in multiples is a direct signature of quantum: in classical world only basic frequency $f = 15$ Hz should have effects (forcing ions to rotational motion around field lines with this frequency.

2. Even multiples of 15 Hz have a weak but non-vanishing effect. Transitions are not possible at all in the lowest order of perturbation theory since the interaction Hamiltonian describing the transitions in question has non-vanishing matrix elements only between states of opposite

parities in the dipole approximation applying when the wavelength of the radiation is much larger than the size of the radiating system [B12]. Odd and even values of n for cyclotron states have opposite parities so that Δn odd rule results. In higher orders of perturbation theory also transitions for which transition frequency is even multiple of the cyclotron frequency are possible. This observation provides additional strong support for the hypothesis that quantum transitions are involved.

There are however also objections.

1. The cyclotron energy scale is about 10^{-14} eV and ridiculously small as compared to the energy scale .086 eV defined by room temperature so that quantal effects should be masked completely by thermal noise.

2. Also ELF em fields at spin flip frequencies (Larmor frequencies) should induce transitions. To my best knowledge these have not been reported.

3. The wave functions of ions in magnetic field are confined in a region of size of order

$$r_n \sim \sqrt{2n/eB} \ ,$$

which is of the order of cell size: macroscopic quantum state is in question. In fact, the value $.5 \times 10^{-4}$ Tesla for Earth's magnetic fields corresponds to the p-adic length scale $L(169) = 5$ μm rather precisely for minimal value of the magnetic flux quantized as $ZeBS = n2\pi$ obtained for $n = 1$ (S denotes the area of the flux tube) and $Z = 2$. If one requires quantum classical correspondence, very large values of n are required and cyclotron radii would be much larger than flux tube radius.

A common resolution of all these objections is provided by large $\hbar$ phases and hierarchy of magnetic flux sheets with B scaling like $1/\hbar$ meaning that cyclotron frequencies scale down similarly and cyclotron energies remain invariant. Same applies to spin flip energies scaling in the same manner as cyclotron energies (for some time I thought that the scaling behaviors are different). By the quantization of the magnetic flux, predicted by TGD also classically, the minimal radius of the magnetic flux tube for the magnetic field of Earth of cell size for ordinary value of $\hbar$ but scales like $\hbar$ if magnetic field remains invariant and flux quantization $BS = n2\pi\hbar$ implying $S \propto \hbar$ holds true. This implies consistency with classical theory for large values of $\hbar$.

7.3.2 A Brief Summary Of The Model Explaining Cyclotron Frequencies

Some work is required to end up with the following interpretation based on a model for how the different levels of dark matter hierarchy communicate and control. This model already discussed at the general level relies on resonant cyclotron transitions induced by Josephson radiation from cell membrane Josephson junctions, which are almost vacuum extremals.

1. Ions with charge Z, mass m and spin S in the external magnetic field behave quantum mechanically like harmonic oscillator with energies quantized as

$$E = E_c + E_L \ , \quad E_c = (n + \tfrac{1}{2})\hbar\omega_c \ , \quad E_L = S_z \tfrac{g\omega_c}{2} \ , \quad \omega_c = \tfrac{ZeB}{m} \ \ (c = 1) \ . \tag{7.3.1}$$

The first contribution corresponds to cyclotron contribution. For a given value of n the component of angular momentum in the direction of B has $n + 1$ values $n, n - 2, ..., -n$. E_L denotes spin (Larmor) contribution. g is so called Lande factor which for free elementary fermions equals to $g = 2$. Since S_z is invariant under the scalings of $\hbar$, Larmor contribution is negligible as compared to cyclotron contribution for large values of $\hbar$. The contribution to energy coming from the free motion in the direction of magnetic field has not been written.

2. Experimental findings suggests strongly that external em field induces resonant transitions between cyclotron states: these transitions are identified as transitions inside the cell/nucleus or its fractally scaled up variant. Cyclotron radiation can drive charged particles to smaller space-time sheets and this is essential for the metabolism and this process is expected to be part of the interaction of ELF em fields with cell nucleus. This in turn induces a response of magnetic body affecting the state of brain.

3. Dark matter hierarchy leads to the hypothesis that there is entire hierarchy of EEGs generated as coherent photon states by Josephson currents associated with the Josephson junctions whose thickness scales as $\hbar$ and frequency scales as $1/\hbar$ so that cyclotron energy remains invariant and is above the thermal threshold. For each value of $\hbar$ there is also p-adic hierarchy corresponding to $k = 151, ..., 169$ with same Josephson frequency: these levels combine to form single block for dark matter hierarchy formed from the scaled up variants of this block. At least the magnetic flux tube structure of DNA and membrane structure appear as scaled up copies. The lowest level corresponds to cellular or nuclear membrane and ordinary value of $\hbar$.

7.3.3 Interpretation Of The Temperature Window

The effects of ELF em fields on matter have been observed only in a temperature window 36-37 C around body temperature. I have already proposed that this interval is due to competition of two effects.

1. High T_c super-conductivity and cyclotron condensates are possible below 37 C whereas near vacuum extremal property is possible above 36 C so that only a narrow temperature range remains making possible communications and control of the biological body by magnetic body.

2. Also the model of high T_c super-conductivity as a quantum critical phenomenon predicts that there is a narrow interval around T_c around which two competing phases corresponding to ordinary value and scaled up value of $\hbar$ compete.

More generally, dark matter hierarchy should correspond to a hierarchy of quantum criticalities. A fractal hierarchy of cusp catastrophes such that the next cusp is inside the critical line of the previous cusp would be a convenient manner to visualize the situation. Each big leap in the evolution corresponds to the emergence of a new level in the dark matter hierarchy made possible by the external conditions allowing co-presence and competition of phases corresponding to different Planck constants.

Quantum critical high T_c super-conductivity for electrons and protons (at least) is the essential prerequisite for the existence of Josephson currents through the cell membrane and its scaled up variants, and thus the hierarchy of generalized EEGs. Electronic super-conductivity is expected to be possible in a very limited temperature range usually idealized with single critical temperature.

Quantum critical phase is analogous spin glass phase possible in a finite interval around critical temperature, and one can indeed speak of quantum spin glass phase for which the analogs of regions with fixed direction of magnetization are 4-dimensional rather than 3-dimensional and static. This relates to the breaking of the strict classical determinism of the basic variational principle of TGD having interpretation in terms of space-time correlate for quantum non-determinism in long time and length scales. Quantum coherence and quantum nondeterminism in long scales is obviously what makes system living. An educated guess is that the critical range of temperatures allowing quantum criticality and high T_c super-conductivity is just 36-37 C: this in turn implies that the effects of ELF em fields occur only in this temperature range.

7.3.4 How Could One Understand The Amplitude Windows?

The attempts to understand the mysterious looking amplitude windows for electric field have not been fruitful hitherto. The intuitive expectation is that the explanation could be in terms of the new physics provided by zero energy ontology and causal diamonds, hierarchy of Planck constants, and

cyclotron frequencies of ions, proton, and electron and even quarks and maybe even Z^0 cyclotron frequency of neutrino. The following argument represents the latex trial based on the model for the DC currents of Becker as quantum currents discussed in [K79].

Can one take into account the complications due to modulation?

Before representing any arguments it must be emphasized that the actual signal is either ELF signal or ELF modulated signal -say microwave signal (frequency in the range is.3 GHz-300 GHz) modulated by cyclotron frequency. The effects are very similar in the two cases. The assumption is therefore that the eventual interaction of the tissue is with ELF frequency signal. This requires demodulation in the tissue. In the case of modulated signal one has to be careful with the experimental definitions of field amplitudes. It will be assumed that the reported amplitude windows correspond in the case of ELF modulated signals to the ELF amplitudes measured in the tissue after de-modulation.

Not that even the question how linear superposition of fields takes place in TGD Universe is non-trivial. For given massless extremal linear superposition is possible only for signals propagating to fixed direction but need not correspond to that for fields since they are not the primary dynamical variables. In fact, the basic argument against TGD is that linear superposition for fields does not hold in TGD Universe in general since classical gauge fields and gravitational field are not primary fields but expressible in terms of embedding space coordinates and their gradients. The solution of the problem is provided by many-sheeted space-time concept (see **Fig.** `http://tgdtheory.fi/appfigures/manysheeted.jpg` or **Fig.** 9 in the appendix of this book). It is not field but their effects which superposed. In classical case the effects are the forces caused by the classical fields. This indeed happens if the fields involved correspond to different space-time sheets and particle suffers simultaneous topological condensation to the space-time sheets in question and experiences the sum of the forces caused by them. In quantum case the sum of gauge potentials and deviations of metric from Minkowski metric is what is experienced by the particle. This is discussed in detail in [K100].

Massless extremals represent the most promising classical description for the radiation fields. They allow arbitrary pulse shapes so that the modulation at the level of massless extremals is not a problem. This kind of modulation is indeed in question. Demodulation requires a highly non-linear mechanism leaving from the rapidly oscillating amplitude only the envelope. In TGD framework it is not difficult to imagine non-linear mechanisms since the dynamics of Kähler action is extremely non-linear. For MEs the time profile of the induced gauge field at given point is essentially arbitrary and one can easily imagine a process leading from ELF modulated field to a pure ELF field at given point. Energy conservation and effective 2-dimensionality of the signal (polarization direction and direction of 4-D wave vector) certainly puts bounds on the change of the amplitude and the simplest guess is that the amplitude squared for pure ELF corresponds to the average of the amplitude squared over the cycle of the carrier wave for the modulated radiation so that amplitude is reduced by $1/\sqrt{2}$ factor.

Direct quantum currents of Becker and explanation for the amplitude windows

The quantum model for the DC currents of Becker 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.

Explanation for the observed amplitude windows

The amplitude window occur in widely separate ranges 1-10 V/m and around 10^{-7} V/m. Of course, also other frequency ranges might be possible. Fractality and the notion of magnetic 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.

By fractality the most natural guess is that the voltage along the flux tube is invariant under the scale of Planck constant. This would mean that the electric field would behave as $1/L^2 \propto 1/\hbar^2$ as a function of the length scale characterizing the scale variant of the structure. If so the range $E = 1 - 10$ V/m assignable also to EEG would correspond to a length scale of $7.7 - 24$ μm corresponding to cell length scale. Perhaps the direct currents run between cells layers. $E = 10^{-7}$ V/m would in turn correspond to 7.8 cm which corresponds to size scale of human brain hemisphere (experiments were carried out for vertebrates). Could the direct quantum currents in question run between brain hemispheres along corpus callosum?

7.4 How Does Generalized EEG Relate To Conscious Experience?

In this section possible interpretation of cyclotron phase transitions and EEG from the point of view of conscious experience are discussed.

7.4.1 Sensory Canvas Hypothesis

Sensory canvas hypothesis assumes that magnetic transition frequencies code for the temporal and possibly also spatial positions of the objects of the 4-D perceptive field at the personal magnetic body characterized by field strength B_{end}.2 Gauss at the surface of Earth. Magnetic transition frequencies are associated with MEs serving as sensory projectors to which various sub-selves representing features are entangled.

The view about evolution of consciousness as a gradual emergence of increasingly lower EEG frequency scales suggests a general paradigm concerning the assignment of the frequency bands with various cyclotron frequencies and possibly spin flip frequencies. 40 Hz band could naturally correspond to MEs projecting symbolic representations associated with the sensory input to the magnetic sensory canvas. The range 20-40 Hz could be associated with some simple cognitive features or emotions (say associated with odor discrimination) whereas 13-20 Hz interval could correspond to more refined cognitive features. alpha and theta bands could relate to the features representing memories. The possibility of communications at theta, delta and alpha frequencies to higher level many-brained magnetic selves representing collective levels of consciousness must be considered seriously in TGD framework.

The processing of the sensory input involves where-what division. The fact that "where" aspect has developed earlier encourages to think that it is more primitive aspect of perception so that the EEG frequencies associated with the simplest "where" aspects might be higher. This is supported also by the fact that the EEG rhythms associated with brain stem and cerebellum correspond to 80 Hz and 200 Hz respectively.

The narrow highly coherent frequency bands with width of order 1-2 Hz reported by Nunez at 3, 5 and 7 Hz, the alpha band at 11 Hz, and the narrow bands at 13, 15 and 17 Hz [**?**] plus the 8 Hz width band around 40 Hz provide empirical support for the basic assumptions and a good starting point for possible more detailed identifications.

7.4.2 Magnetic Quantum Phase Transitions And EEG

The original attempt to assign our qualia to magnetic and Z^0 magnetic transitions need not be correct. The following scenario looks a more realistic working hypothesis.

1. The EEG MEs associated with magnetic transitions serve as quantum entanglers of the bodily mental images to the personal magnetic body. If sensory representations are realized at the personal magnetic body, the magnetic quantum phase transitions at the personal magnetic body contribute to our conscious experience by the fusion of "simple feeling of existence" mental images with much more complex bodily mental images.

2. The field patterns associated with negative energy EEG MEs code for declarative long term memories perhaps using the hierarchy of p-adic cognitive codes discussed above. The model of long term declarative memories suggests that bodily magnetic qualia need not be conscious-to-us. The magnetic quantum phase transitions would represent a step in the transformation of the field patterns of EEG MEs representing declarative memories to conscious experiences.

The overall conclusion would be that, as far as primary sensory qualia are considered, magnetic transitions are not very interesting. On the other hand, the hypothesis that magnetic fields are such that magnetic transition frequencies tend to coincide with various universal frequencies (say those assignable toCDs), makes them very interesting concerning the practical models for what might be happening at the magnetic flux tubes of body and brain.

Sensory maps by magnetic frequency scale coding

There is a large temptation to assume that the great variety magnetic magnetic transitions in EEG frequency range make possible hierarchy of living maps. A varying magneti frequency scale would code for a position of neuron or some larger unit of brain and to which input from a point of perceptive field is mapped by entanglement (sharing of mental images) and/or by classical communications. Personal magnetic body would essentially remember what happens at material body by sending entanglement inducing negative energy ME to brain along magnetic flux tube and receiving positive energy MEs inducing self-organization and generation of mental images. The classical communication would be like communicating selectively by broadcasting radio waves to receivers each having their own narrow radio wave band.

The working hypothesis is that various mental images in the cortex are projected outside the cortex and CNS at the canvases formed by the magnetic flux quanta associated with various body parts. There are good reasons to believe that these maps are realized in the length scales of EEG wavelengths. The resulting 3-dimensionality of the map is a strong argument in favor of these maps as also the complete decoupling between representation and information processing yielding the representation.

Quantum maps could be realized by place coding using cyclotron frequencies associated with ELF MEs emerging radially from various parts of CNS, also from sensory organs even. If the time mirror mechanism (see **Fig.** `http://tgdtheory.fi/appfigures/timemirror.jpg` or **Fig. ??** in the appendix of this book) is a general mechanism of sensory perception, motor action, and memory applied by the magnetic body, the length along the magnetic flux tube codes for the temporal distance to the geometric past. This coding would rely on resonance mechanism involving also resonant interaction of MEs with Alfven waves associated with magnetic flux tubes (much like oscillations of string). The very slow dependence of these frequencies on distance would be determined by the strengths of the classical magnetic fields for which these flux tubes provide a representation as topological field quanta.

Positive energy magnetic transitions could be used for the temporal coding of the sensory representations whereas negative energy magnetic transitions could be used for the temporal coding of generalized motor actions. This would obviously help to avoid overlap between signalling associated with sensory representations and motor actions.

Magnetic quantum phase transitions could give rise to chemical maps of parts of organ. By using an appropriate value of frequency, magnetic quantum phase transitions can be induced and the intensities of these transitions would provide conscious measure for the densities of Bose-Einstein condensates of ions (and perhaps even their Cooper pairs if they manage to be thermally

stable) whose densities in turn relate to those at atomic space-time sheets by many-sheeted ionic equilibrium conditions. If the thickness of the magnetic flux tube varies different quantum phase transitions occur at different points of the flux tube and kind of conscious spectrogram results. This kind of generalization of NMR spectroscopy need not be conscious to us although chemical senses could relate to it.

Place coding for the geometric parameters characterizing simple geometric features

Place coding for various geometric parameters characterizing simple geometric "features" could be realized using the variation of the cyclotron frequency along a magnetic flux tube of varying thickness. The hierarchy of the sensory canvases allows a modular structure in which a geometric feature such as triangle, line, or ellipse represented at a lower level sensory canvas is projected to a *single* point of "our" sensory canvas. If one accepts that only negative energy MEs can serve as entanglers, the conclusion would be that place coding must utilize negative energy MEs to entangle brainy mental images with the "simple feelings of existence" at the magnetic body.

Becker tells in his book "Cross Currents" [**?**] about a technique discovered by Dr. Elizabeth Rauscher, a physicist, and William Van Bise, an engineer. The technique uses magnetic fields generated by two coils of wire, each oscillating at a slightly different frequency and directed so as to intersect at the head of the subject person. When two energy beams with different frequencies intersect at some point in space, a third frequency, so called beat frequency is formed as the difference of the frequencies. What Bise and Rauscher found that this ELF frequency (unfortunately, I do not know what the precise frequency range was) generates simple visual percepts like circles, ellipses and triangles and that the variation of the second frequency induces the variation of the shape of the percept.

The simplest interpretation is that the beat frequency is extracted by non-linear effects in brain and induces a magnetic quantum phase transition at magnetic tubes whose thickness varies and codes for a parameter (say scaling in some direction) characterizing the geometry of the primitive percept (or "feature"). The proposed general mechanism for how EEG MEs give rise to declarative memories should apply also now and would mean that EEG MEs induce cyclotron transitions giving in turn rise to neural activity. If primary sensory organs are seats of sensory qualia, back-projection to the eyes is involved with the process as also in the case of electric stimulus of cortex inducing visual sensations. The intersection of ELF waves would wake-up symbolic mental images representing triangle and back-projection would make this concept visual. The geometric parameters characterizing the triangle would be coded to frequency differences. An analogous phenomenon occurs also for auditory inputs with slightly different frequencies fed into ears and makes it possible to "hear" sounds below the audible range. The mechanism could be the same.

Flag-manifold qualia and magnetic fields

Recall that the flag-manifold representing various choices of quantization axes is a coset space associated with the zero modes. The association of the six-dimensional flag-manifold of color group $SU(3)$ to honeybee dance and geometric aspects of honeybee's sensory experience (described in the chapter [K45] inspired the hypothesis that the values of the flag manifold coordinates might be quite generally mapped to magnetic or Z^0 magnetic frequencies by mapping these coordinates to the parameters characterizing magnetic flux tubes. Thus there are two frequencies involved and the mappings projects everything to 2-dimensional space.

The flag-manifold defined by the choices of the quantization axes for the super-symplectic algebra of the WCW is infinite-dimensional. One can however consider finite-dimensional flag-manifolds as lowest order approximation. In the case of MEs of type $E^2 \times CP_2$, the minimal flag-manifold would be the one defined by the Cartan group of $SO(2) \times SU(3)$, which is just the flag-manifold $F_3 = SU(3)/U(1) \times U(1)$ of color group introduced by Barbara Shipman. For MEs of type $S^2 \times CP_2$ which correspond to spherical light fronts the flag manifold is $S^2 \times F_3$. A very natural identification of S^2 is as labelling orientations of a vector in 3-space. Thus one might consider the possibility that the increments S^2 coordinates could represent changes of orientation at the level of conscious experience. On the other hand, linear sequence of sub-selves inside self would represent experienced orientations very concretely.

One could try to generalize, and consider the possibility that the proper flag manifold is defined by $SO(3,1) \times SU(3)$ by the division by Cartan subgroup. Lorentz group would give 4-dimensional flag-manifold $SO(3,1)/R \times SO(2)$. Lorentz rotations can be decomposed to boosts followed by rotations in rest frame of the resulting system. This suggests that $SO(3,1)$ flag-manifold has a bundle structure with the sphere S^2 defined by boost directions serving as the base and the sphere S^2 defined by the possible directions for the axis of rotation in the rest frame serving as the fiber. Again sub-self moving inside self could represent the direction of boost naturally.

There must be some correlation between the values of zero modes (in particular, flag manifold coordinates) and classical em Z^0 magnetic fields. For instance, color rotation affects the em and classical Z^0 fields. In this sense flag-manifold coordinates can be coded to em and Z^0 magnetic frequencies but the image is 2-dimensional. The work of Barbara Shipman with the dance of honeybee indeed implied that flag-manifold coordinates are mapped to spatial positions in *2-dimensional* plane representing the dance stage. This suggests that $F_3 = SU(3)/U(1) \times U(1)$ coordinates have representational role: they represent concrete geometric information about spatial positions. This representational role could derive from more general assumptions. The positions of plane are represented as frequencies by the place coding by magnetic and Z^0 magnetic frequencies and $SU(3)$ rotations affect em and Z^0 magnetic frequencies so that plane points can be mapped to equivalence classes of $SU(3)$ rotations so that a 2-dimensional space associated with the flag-manifold F_3 emerges naturally.

Could magnetic phase transitions define sensory qualia?

If universality principle holds truemagnetic qualia can be divided to universal kinesthetic qualia and to generalized chemical qualia corresponding to the change of a number of particles in a state with given quantum numbers (say the integer n characterizing cyclotron state). The interpretation of these qualia is far from obvious.

1. Magnetic qualia could be "universal feelings of existence" associated with the place coding of the motor actions from the sensory canvas and also inside brain. This would mean a neat separation of sensory and motor representations from each other. Universal feeling of existence might also be the basic aspect of tactile senses and in fact, all sensations.

2. If the harmonic of the cyclotron frequency does not affect the character of the quale, the number of cyclotron qualia is finite. alpha band is expected to be the most interesting frequency range as far as qualia are considered. The five bosonic ions $Mn^{2+}, Fe^{2+}, Co^{2+}, Zn^{2+}$, and Se^{2-} have cyclotron frequencies 7.6, 9.4, 10.0, 10.8 and 11.4 Hz. The number of basic tastes is thought to be five, which could mean that magnetic cyclotron phase transitions code for the basic tastes. The number of odors is definitely larger than basic tastes as is also the number of exotic Z^0 ions, which are almost always bosons. Thus the identification of Z^0 magnetic cyclotron transitions as correlates for odors can be considered.

This proposal can be criticized. Any bosonic molecule with $A/Z \leq 223$ (thermal stability of the BE condensate at room temperature) could as such directly define a cyclotron quale so that tastes and odors would correspond to cyclotron transitions of molecules themselves rather than those of bosonic ions in alpha band. One could also argue that the odors and tastes should have a natural ordering according to the value of cyclotron frequency and be continuously transformable to each other by changing the strength of the magnetic field. This doesn't seem to be the case.

What about Larmor frequencies?

Larmor frequency characterizes the nuclear contribution of this interaction to energy and is related to the cyclotron frequency of a singly ionized atom by

$$\omega_L = g\frac{S}{2}\omega_c \quad , \quad \omega_c = \frac{eB}{m} \quad .$$

where S denotes the maximal projection of spin in the direction of the magnetic field and g is Lande factor, which equals to $g = 1$ in the ideal classical case for which spin corresponds to angular momentum whereas $g = 2$ holds true for elementary fermions. Nuclear contribution is the dominant contribution for ions Na_+, K_+, Cl_- since electron shell is full for the ions in question.

The magnetic moments of ions Cl_-, K_+, Na_+ reduce to their nuclear magnetic moments and are rather large:

$$\mu = x\frac{e}{2m_p}S \quad , \quad g \simeq 2xA \quad ,$$

where m_p denotes proton mass and x is a parameter of order one so that Lande factor is proportional to the mass number A of nucleus. The reason for large value of μ is that magnetic interaction energy of the nucleus is essentially the sum over the interaction energies of nucleons.

If anomalous magnetic moment vanishes Larmor frequency differs by a factor 1/2 from cyclotron frequency: $f_L = f_c/2$ so that spin flip frequency is same as cyclotron frequency. For atomic nuclei the Larmor frequency tends to be larger than cyclotron frequency as the table of Appendix demonstrates. The effects of em fields in living matter at Larmor frequencies have not been however reported.

The interaction of the nuclear spin with magnetic field dominates over the cyclotron interaction energy by a factor of order A and that the natural frequency scale for the ionic Larmor frequencies is hundreds of cycles per second. The values of the parameter x are $x(Na) = 2.214$, $x(Cl) = .82181$ and $x(K) = .3915$. For instance, for Na_+ spin flip transition frequency with $\Delta S = 1$ is $f \sim 222$ Hz. For Ca_{++} spin and magnetic moment vanishes. Note that for $J = 3/2$ ions there are in principle three kinds of transitions corresponding to $\Delta S = \pm 1, \pm 2, \pm 3$. If transition reduces to single nucleon level, $\Delta S = \pm 1$ is the only possibility. The conclusion is that Larmor frequencies probably correspond to different components of sensory modalities than cyclotron frequencies.

The transitions changing the direction of spin of the Cooper pair are induced by the frequencies

$$\omega = (2n+1)\omega_c + 2\Delta m\omega_L = (2n + 1 + g\frac{\Delta m}{2})\omega_c \quad .$$

Odd multiples of the cyclotron frequency are possible in the first order perturbation theory whereas even multiples are possible only in the second order.

The natural question is whether also spin flips to which Larmor frequencies are associated could be also important from the point of view of conscious experience. The natural expectation is that Larmor frequency behaves in the same manner as cyclotron frequency in the scaling of Planck constant and this is indeed the case since spin scales as $\hbar_{eff}$. This allows to consider the possibility that also spin flip transitions are of interest and perhaps define correlates for sensory qualia.

Consider now some examples.

1. For proton and neutron the Lande factors are $g(p) = 3.58$ and $g(n) = -3.82$ so that the spin flip transition frequencies in Earth's magnetic field would be $2\omega_L = 542$ cycles/second for proton and 570 cycles/second for neuron. The frequencies $2f_L$ and $2f_L + f_c = 842$ cycles/second could have something to do with the time scale of nerve pulse in case of proton. Note that $2f_L - f_c = 242$ cycles/second is of same order as f_c for proton so that corresponding qualia might resemble each other.

2. For electron $g = 2$ in excellent approximation and the Larmor frequency is very nearly identical with one half of cyclotron frequency. The deviation is

$$\frac{\Delta g}{g} = \frac{\alpha}{2\pi}$$

in the lowest order of perturbation theory ($\alpha \simeq 1/137$) and thus the frequency for the transition $(n+1, up) \leftrightarrow (n, down)$ changing the spin direction of the second electron of the Cooper pair is $\omega \simeq 902$ Hz. This time scale corresponds to the duration of memetic codon fixed by the fact that memetic code corresponds to Mersenne prime M_{127}, which happens to be the p-adic prime characterizing also electron.

3. Spin flip frequencies for atomic nuclei are in general of order few hundred Hz for $B = .2$ Gauss. For instance, the spin flip frequencies of Mn, Co, Cu, and Na are for $B = .2$ Gauss 228 Hz, 199 Hz, 223 Hz, and 222 Hz. What makes this interesting is that cerebellar resonance frequency is around 200 Hz.

Ion	(Z, A, S)	f_1/Hz	f_{flip}/Hz	J
Cl	(17, 35, F)	8.5	82.2	3/2
K	(19, 39, F)	7.5	39.1	3/2
Rb	(37, 85, F)	3.5	81.0	5/2
Y	(39, 89, F)	3.4	41.2	1/2
Rh	(45, 103, F)	2.9	26.6	1/2
Ag	(47, 107, F)	2.8	34.2 (39.2)	1/2
Ir	(77, 193, F)	1.6	17.0	3/2
Au	(79, 197, F)	1.5	14.0	3/2

Table 7.1: The ions for which electronic spin vanishes in ground state and minimum spin flip frequency f_{flip} is below 90 Hz. f_{flip} is defined as $f_{min} = 2f_L/J$m, where J is nuclear spin. Ag allows two stable isotopes with almost same abundances and the values of f_{flip} are given for both.

The eight ions listed in **Table 7.1** have however exceptionally low Larmor frequencies and, very importantly, the singly ionized states have vanishing electronic spin for all ions except Rh and IR for which electronic configuration corresponds to $J - e = 2/2$ (non-vanishing electronic spin implies that the Larmor frequency of ion is of order $f_L = f_c(e)/2 \simeq 3 \times 10^5$ Hz). This suggests that electromagnetic spin flip transitions for these ions at least could be related to our consciousness. Note that K, Ag and Au have spin flip frequencies near to the harmonics of the fundamental frequencies of exotic super-symplectic representations important in EEG frequency range. Note that the spin flip frequency of K is 39.1 Hz which is in 40 Hz thalamocortical resonance band. The spin flip frequency 82.2 Hz for Cl might relate to the resonance frequency 80 Hz associated with retina.

Magnetic states have momentum in the direction of the magnetic field and a priori the transition frequency spectrum is continuous rather than discrete. Energy and momentum conservation however imply that the increment of longitudinal momentum is fixed in transition and in excellent approximation transition energies are equal to those obtained by neglecting longitudinal momenta altogether.

To get an idea about energy and momentum transfers involved with the transitions between magnetic states with longitudinal momenta k_1 and k_2, one one apply energy and momentum conservation by assuming that the classical field associated with ME, and thus propagating with light velocity, induces the transition. Let k_1 and k_2 denote the wave vectors of initial and final magnetic states in the direction magnetic field: the corresponding contributions to the energies of the magnetic states are $k_i^2/2m$, $i = 1, 2$. Let $k_{||} = kcos(\theta)$ denote the projection of the wave vector k of the ME em wave to the direction of the magnetic field satisfying $k = E$: momentum conservation gives $k_1 - k_2 = k_{||}$. Energy conservation in turn gives

$$\Delta E = \Delta E_B + \frac{k_1^2 - k_2^2}{2m} = E \ ,$$

where

$$\Delta E_B = n\omega_c + \omega_{flip}$$

denotes to the contribution of the cyclotron and spin flip components to the transition frequency. The condition

$$(k_1 + k_2)/m << 1$$

is certainly satisfied and this allows the approximations

$$k = \Delta E \simeq \Delta E_B$$

$$k_1 - k_2 \simeq \Delta E_B cos(\theta)$$

The result means that transition frequencies are not essentially affected by the energy transfer in longitudinal degrees of freedom and it is an excellent approximation to assume that the fre-

quencies inducing magnetic transitions correspond to the transition frequencies associated with the transitions in cyclotron and spin-flip degrees of freedom.

7.4.3 Altered States Of Consciousness And EEG

The magnetic flux tubes in the length scale range determined by theta and delta band could quite well connect magnetic body to several different organisms and make possible sharing of experiences. Also magnetosphere and even larger magnetic structures could give rise to sensory and other representations receiving input from several organisms and sharing of mental images would allow to share these experiences.

If magnetic body is the experiencer applying time mirror mechanism and if positive energy EEG boundary MEs in delta and theta bands correspond to classical communications of declarative memories usually not conscious-to-us, the dominance of theta and delta waves during sleep suggests two alternatives.

1. During the sleep our attention is directed to transpersonal levels of consciousness but that we do not remember anything about this. The reason might be that no declarative memories are generated during this period.

2. We are entangled with transpersonal levels of consciousness and have lost our personal consciousness. A conscious contact with transpersonal levels requires sharing of mental images with these levels and this might occur during meditation. Theta and delta bands are also known to dominate during deep meditation.

One can consider two alternative interpretations corresponding to interior MEs (phase velocity equal to light velocity) and positive energy boundary MEs (phase velocity equal to EEG phase velocity) associated by scaling law with the negative energy MEs.

1. For positive energy interior MEs the frequencies would correspond to magnetic flux tube lengths up to about 10 Earth circumferences and contained within Earth's magnetotail at the night side. Time scale would be $T = 1/f$. These MEs could feed data using appropriate cognitive codes at p-adic resonances frequencies to the magnetospheric multi-brainy collective selves responsible for the transpersonal levels of consciousness.

2. The scaling law, assuming the alpha wave phase velocity to be the effective phase velocity v of boundary ME, would predict that the time $T_1 = \lambda/v$ needed by the boundary MEs to travel the distance $L = c/f$ defining the distance to the point of the magnetic body wherefrom the negative energy EEG ME was sent to the brain, is measured using decade as a natural unit. If magnetic body is the experiencer applying time mirror mechanism this would mean that delta band would correspond to memories with time span of about ten years. One might think that the magnetic body triggers boundary MEs using negative energy MEs in ULF range which automatically give rise to memories experienced after time T_1.

Transcendental states of consciousness and EEG

Transcendental states of consciousness are characterized by the presence of alpha and theta bands [**?**] (note that theta band is present also during childhood, youth and even early adolescence but usually disappears at older age). It is found that theta and alpha bands are preserved also during deep sleep [J5]. A possible interpretation is that the presence of alpha band signifies that left brain remains awake in a state of relaxed alertness involving weak signals from magnetic body. One could also argue that even deep sleep is a conscious state but that the presence of alpha band activity in left brain is necessary in order to have memories about this state.

Transpersonal levels of consciousness

Individual organisms or even larger structures could define the "pixel size" for higher level multi-brained selves realized as sensory, symbolic and cognitive representations at various magnetic structures like the magnetosphere of Earth. These levels could correspond to any p-adic length

scale above brain size. These levels would obviously represent the consciousness of various kinds of groups and collectives.

1. Sleep and transpersonal states of consciousness

The simplest assumption is that one loses consciousness during sleep by entanglement with some higher level self, say magnetospheric multi-brained self. This would give rise to a fusion of mental images at this higher level and to a stereo consciousness representing "human condition".

One should not be however too hasty to make this kind of conclusion. If it is indeed biological body which sleeps, our field body could be full awake with attention directed to transpersonal levels of existence. If this is indeed the case, the basic question would be about how to have these experiences and simultaneously form long term declarative memories about them: some part of brain, probably including hippocampus, should be kept awake during these experiences. Perhaps meditative states, often characterized as transpersonal ego-free consciousness, are this kind of states.

2. Who am I?

These arguments raise the question "Who am I really?". What precise length scale my ME does corresponds size of Earth, of solar system, of galaxy? Or can my self size be literally infinite and correspond to some infinite p-adic prime and is only the localization for the contents of my conscious experience to this particular corner of this particular galaxy which creates the illusion that I am this biological body? During episodal memories and also ordinary memory recall parts of magnetic body and MEs having size $L = cT$, T the time span of the episodal memory are actively involved so that one can say that the size of "me" is measured in light years. But it is difficult to say whether the contents of my consciousness contains only personal memories even in ordinary states of consciousness. For instance, it is difficult to locate mathematical ideas in any particular portion of space-time and p-adic space-time sheets which are infinitesimally small p-adically are infinitely large in real sense.

Whatever the detailed answer to these questions is, this view allows to interpret physical death as a re-directed attention and giving rise to what might be called re-incarnation. What would differentiate between my and my dog's soul that our attentions are differently directed.

3. Examples of transpersonal experiences

Near-death experiences and out-of-body experiences could be examples of of almost transpersonal, "ego-free" consciousness. That these experiences often involve the experience of seeing one's own body from outside, is consistent with the transpersonal nature of the experience. As already noticed, delta band is peak frequency in the EEG of infant, which would suggest that children either direct their attention mostly to the transpersonal levels or that children are strongly entangled and almost unconscious as also we are when theta and delta bands of EEG dominate. That this would be the case would conform with the ideas about bicamerality. Otherwise our personal development would be gradual spiritual degeneration.

The experiences of what I call whole-body consciousness could also be example of consciousness involving transpersonal component. These states appear often at night time as dream like experiences and involve illusion of being in ordinary wake-up consciousness. The usual "noise" present everywhere in body, possibly due to the averaging over proprioceptive experiences of subselves, disappears totally and peculiar silence falls down. Whole-body consciousness starts as a stir in spine (same as generated by good music sometimes) extending gradually to the entire body. Experiences of weightlessness and of "wavy" nature of physical body, flying into roof and falling down smoothly back into bed are typical aspects of these experiences. During this kind of experience it is sometimes also possible to leave the room. During my "great experience" I experienced of leaving the hospital and walking along street knowing that I was invisible. This experience ended to experience of being brought back to hospital by hospital personnel.

Short lasting form of whole-body consciousness is also possible after waking-up immediately after falling asleep in daytime: perhaps theta consciousness prevails for a short time after wake-up. My personal "great experience" involved besides whole body consciousness enhanced cognition: entire flux of ideas many of which have later developed to basic principles of quantum TGD.

Meditative states of consciousness and EEG

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The proposed general picture allows to build a rough model for the mechanism leading to meditative states. One can also understand how so called ORMUS elements [H3] might help to achieve these states.

The harmonics of cyclotron frequencies in delta band should represent even more deeper transpersonal qualia with time scale of about $t_1 = (c/V) \times T$, $T = 1/f$ light years for $f = 1.5$ Hz and $V = 3$ m/s. One could of course argue that the concentrations of heavy ions in brain are so low so that corresponding cyclotron transitions do not give rise to any experiences even if scaling law would not forbid them. This objection is not necessarily very convincing since the needed densities of ions in cellular space-time sheet might be by a fraction of order $[L_e(137)/L_e(167)]^3 \sim 10^{-13}$ smaller than density of water and because heavier ions are in gas form and presumably tend to be mostly in non-atomic space-time sheets. TGD predicts also new electro-weak physics would could dramatically change the isotope ratios at cellular space-time sheets.

Delta waves might relate to the interaction of brain with sferics which are atmospheric em perturbations [F6]. The spectrum of sferics at delta frequencies resembles EEG spectrum at same frequencies [F6]. The electric fields associated with sferics are of same order of magnitude as waves in delta band so that they are not amplified as much as alpha waves. This could explain why delta and theta consciousness is so weak.

One could also consider enhancing delta consciousness artificially: perhaps this could make enlightenment experience, if not more probable, at least more intense. This could perhaps be achieved by feeding in brain some heavy singly ionized ions with cyclotron frequencies in delta band and stimulating brain using ELF em field at corresponding cyclotron frequency in $B_{end} = 0.2$ Gauss. Some candidate ions are $Ag^+ : f_c = 2.8$ Hz; $I^+ : f_c = 2.4$ Hz and $Au^+ : f_c = 1.5$ Hz. Also heavy ions like Hg and Pb are in the same frequency range as Gold. For $Z = 1$ flux quantization these frequencies are halved since magnetic field strength is halved.

There are claims for so called ORMUS atoms which somehow differ from ordinary atoms [H3]. The persons involved take doses of what they call ORMUS elements, in particular so called White Gold, to induce spiritual experiences. In fact, Barry Carter who wanted to understand what is involved, contacted me about five years ago and told about these effects and I ended up the notion of wormhole Bose-Einstein condensate as a possible explanation of the claimed properties of White Gold. It might be that Gold ions and other heavy element ions enhance transpersonal sensory consciousness in delta band and lead therefore to spiritual experiences.

There is also a patented process developed by Robert Monroe and called Hemi-Synch [**?**] which might induce delta and theta consciousness. Feeding audible sounds to ears with carrier frequencies below kHz and frequency difference of say 10 Hz, which is as such not audible, generates binaural beat involving appearance of an EEG wave at difference frequency [**?**]. The difference frequency is not only "heard" but binaural beats in delta and theta range tend to induce relaxed, meditative and creative states [**?**]. This method might provide a test for the hypothesis that linear combinations or p-adic frequencies are crucial for consciousness by choosing beat frequencies equal to these frequencies. In a similar manner one could test the alternative hypothesis that cyclotron frequencies are fundamental for consciousness. One should know the precise value of local magnetic field and also take into account the possibility that brain could be able to regulate the value of the local magnetic field to some extend. It could be also possible to apply EEG biofeedback and delta and theta frequencies.

Empirical evidence for transpersonal levels of consciousness

Recall that hyper-genes would correspond to flux sheets traversing through cell nuclei belonging to several organisms. Obviously this level would correspond to a transpersonal level of consciousness: kind of multi-brained conscious entities receiving sensory input from several organisms and performing intentional control over their behavior would be in question. Strong correlations between EEGs of individuals, in particular those having a close personal relationship, would be the obvious implication.

The experiments of Mark Germine [**?**] provide evidence for the notion of transpersonal conscious entities and associated collective memory perhaps realized in terms of flux sheets traversing

the neuronal nuclei of several persons. What was studied was the evoked EEG response to a series of random quantum stimuli which consisted of series of identical sound stimuli with randomly located deviant stimulus. Two subject persons, A and B, were involved. In the case that A observed the differing stimulus 1 second before B, the evoked EEG response of B became incoherent. Since evoked stimulus was oscillation at EEG frequency of about 11 Hz in the case that A had not observed the stimulus, one could understand the mechanism as a direct evidence for transpersonal conscious entity interacting with brains of both A and B. When transpersonal conscious entity had hear the stimulus once, it did not react to it in similar manner.

7.4.4 EEG And Golden Mean

Dan Winter has reported [H2] that in certain altered states of consciousness (described as experiences of bliss) the ratio of beta and alpha peaks approaches Golden Mean $\Phi \simeq 1.618...$ It is interesting to look what TGD based model for EEG could say about this finding.

1. For $f_J = 5$ Hz and $f_c = 10$ Hz (the p-adic frequency corresponding to the secondary p-adic time scale $T_2(127)$ associated with Mersenne prime M_{127}, and identifiable as a fundamental biorhythm) one has $\beta/\alpha = 3/2$ which is the lowest approximation to Golden Mean in terms of ratios of Fibonacci numbers. The higher approximations approach to Φ. The approximation sequence would be consistent with the 1 Hz width for the narrow beta bands.

2. This would suggest that beta/alpha ratio is maximal in this state and approaches to Φ in a discrete manner. The question is whether the resting potential is quantized in terms of ratios of Fibonacci numbers $F_{2n}/F_{2n-1} \in \{3/2, 8/5, 21/13, ..\}$. At the limit theta peak would approach to 3.92 Hz: note that shamanic drumming rhythm corresponds to 4 Hz frequency. This hypothesis is testable by comparing possible changes in the measured resting potentials with subjective reports of meditators.

3. The sequence of ratios of F_{n+1}/F_n approaches Golden Mean in an oscillatory manner, which suggests that states of hyper-polarization following generation of nerve pulse correspond to ratios $F_3/F_2 = 5/3$, $F_8/F_5 = 13/8$, ... above Golden Mean. In the sate of "full bliss" there would be no hyper-polarization after the generation of nerve pulse. A possible interpretation is that there is no "dead" time after nerve pulse and system is immediately in a state of maximal possible alertness. On the other hand, the state of pure bliss should be ideally a state of pure alertness without mental images. In the state in which cell membrane in resting state is maximally hyperpolarized, nerve pulse generation does not occur too easily and thus sensory or other mental are not easily generated.

4. The sequence of Fibonacci numbers could relate to a hierarchy of finite-dimensional approximations for Jones inclusions for quantum phase $q = exp(i\pi/5)$ represented in terms of braids. $n = 5$ is also the minimal value of n allowing universal topological quantum computation [K3]. The state of full bliss would correspond to the limit at which the number of strands of braid is infinite so that topological quantum computations resources are maximal.

5. Dan Winter has also emphasized the importance of tetrahedral and icosahedral symmetries for DNA. These symmetries correspond to the only genuinely 3-dimension finite subgroups of rotation groups and are symmetries of water molecule clusters. Icosahedral group has $n = 5$ and would allow universal topological quantum computation.

7.4.5 Pineal Gland And EEG

Pineal gland is an unpaired structure and strictly speaking not part of brain being located outside the brain in primitive vertebrates. Pineal gland is known to play a role in the control of both central nervous system, endocrine system and immune system [**?**] . There is also strong evidence that pineal gland forms part of the magnetic navigation system in birds, and possibly also in humans who also have this system. Pineal gland is biological timekeeper and responsible for 24-hour circadian rhythms via a secretion of hormones, in particular melatonin. What pineal gland does is to inhibit secretion whereas pituitary gland facilitates it. Pineal melatonin level controls

the hormone secretion and sleep wave cycle and magnetic exposure changes pineal melotonin secretion [**?**].

What makes pineal gland interesting is that it is accompanied by 10 Hz rhythms. This rhythm corresponds to the strongest resonance frequency in the alpha band for both EEG and ZEG.

Pineal gland as timekeeper

10 Hz corresponds to the p-adic frequency $f(2,127)$ associated with the 126-bit memetic code, which is an especially important code in the hierarchy of the cognitive codes. The fact that tiny electric field at average alpha frequency of 10 Hz restores biorhythms in absence of local magnetic field [**?**], suggests that pineal gland has a coupling to some cavity resonances or some magnetic transition frequency equal to 10 Hz.

1. The lowest Schumann frequency 7.8 Hz is too low. On the other hand, the resonance frequency associated with effectively two-dimensional excitations of em fields inside Schumann cavity is exactly 10 Hz and could be involved with the realization of the memetic code.

2. Fe^{++} ion appears naturally and has cyclotron frequency of 10.74 Hz and provides a natural candidate for a biological clock, not necessarily associated with the pineal gland. A 3 per cent reduction of the Earth's magnetic field from the nominal value of.5 Gauss would reduce the cyclotron frequency to 10 Hz.

3. Co^{++} cyclotron frequency would be 10 Hz for $B = .5$ Gauss. Co^{++} has very high nuclear spin and is therefore a natural magnet: Yarrow has indeed suggested that vitamin B_{12} containing Co makes pineal gland magnetic hormone and fundamental biological clock at 10 Hz frequency [**?**]. Thus at least ELF ME with Co^{++} cyclotron frequency should go through pineal gland. In the case that they are singly ionized $n = 2$ multiples of corresponding cyclotron frequencies would be involved with the biological clocks in question: these transitions are possible in the second order of perturbation theory.

In darkness 24-hour circadian rhythm changes to 25-hour rhythm perhaps defined by the rotation of Moon and Earths's own rotation. The ratio of 24-hour period to 25-hour period is .96. The ratio of the average of Co^{++} and Fe^{++} frequencies to Fe^{++} frequency is .964 giving period of 24 hours 53 minutes if the average period is 24 hours. This observation suggests that circadian period is measured during daylight in time unit given by the period of Fe^{++} rhythm possibly associated with some visual pathway, perhaps even with eyes, and in darkness by the slightly slower Co^{++} rhythm associated with the pineal gland. Under this assumption the ordinary circadian rhythm f is weighted average of Fe^{++} and Co^{++} rhythms:

$$f = xf(C0^{++}) + (1-x)f(Fe^{++}) \ ,$$

In ideal circumstances circadian rhythm is 24 hours: this gives $x = .44$ with roughly 13.5 day hours and 10.5 dark hours. In continual darkness the rhythm would transform to the slower Co^{++} rhythm of 25 hours with $f = f(Co^{++})$. These two rhythms would presumably distinguish between sleep and awake since pineal gland closely related to the regulation of sleep-wake cycle.

The deviation of x from ideal value $x = .44$ could be an important factor in some disorders. It is known that human melatonin levels do not depend very strongly on season except in arctic latitudes (seasonal affective disorder) but that melatonin levels affect sleep-wake cycle. Abnormally high activity of pineal gland is associated with the hallucinatory periods of schizophrenia: perhaps visual hallucinations of schizophrenic are partially mediated by pineal gland. The manic (depressive) phase of bipolar disorder correlates also with over- (under-) activity of the pineal gland [**?**]. Keeping x by artificial lighting near its ideal value could be of help. The artificial modification of the strength of the local magnetic field should modify the unit of biological time: perhaps this could provide a manner to cure not only jet lag but even much more serious mental disorders.

Pineal gland as "third eye"

The question is whether the 25-hour rhythm equals to the rhythm defined by moon's rotation or is it a mere coincidence. If not, then the MEs going through through pineal gland might mediate unconscious-to-us information about the rotation of Moon. Could higher level self "see" moon in its orbit? Perhaps in some sense! The ability to restore circadian rhythms is based on the photosensitivity of the pineal gland. Pineal gland has been indeed regarded as "third eye" by mystics. As a matter fact, in some lower vertebrates pineal gland serves as a genuine eye [**?**]. For long it has been thought that in mammals pineal gland is not (or perhaps cannot be!) directly photosensitive. Indeed, there is a pathway from the retinas to the hypothalamus called the retinohypothalamic tract [**?**]. It brings information about light and dark cycles to a region of the hypothalamus called the suprachiasmatic nucleus (SCN). From the SCN, nerve impulses travel via the pineal nerve (sympathetic nervous system) to the pineal gland. These impulses inhibit the production of melatonin. When these impulses stop (at night, when light no longer stimulates the hypothalamus), pineal inhibition ceases and melatonin is released. The pineal gland is therefore a photosensitive organ and an important timekeeper for the human body.

The belief that pineal gland receives information about changes in the lighting from retinas only, has turned to be wrong: mammals lacking ordinary rods and cones genetically, can preserve they circadian rhythms [**?**] ! Thus pineal gland must perceive changes in lighting somehow. TGD based explanation for pineal vision is based on the many-sheeted space-time concept (see **Fig.** `http://tgdtheory.fi/appfigures/manysheeted.jpg` or **Fig.** 9 in the appendix of this book) and ELF selves: light reaches pineal gland via MEs associated with EEG frequencies. Why we do not then see with our third eye? Or do do we actually see?: perhaps visual dreaming involves also seeing with the third eye providing "spiritual input" ! This hypothesis can be tested by checking whether the dreams of people with pineal gland injury somehow change. This explanation also suggests that also eyes are foci of converging MEs so that eyes would be rather concretely mirror of the soul!

Perhaps Descartes was not so wrong after all!

Descartes has been ridiculed for his belief that pineal gland is the seat of soul. Perhaps this sentence has been precipitate as suggested by a clinical case in which over-activity of 5-year old child had led to premature adolescence. Here is a fragment from Frederic Tilney's book "The Pineal Gland":

Until a few decades ago scant attention was paid to the pineal gland. Then came the case, noted by Dr. Berman, in which a child was brought to a German clinic suffering from eye trouble and headaches. He was five years old and very mature, and apparently had reached the age of adolescence. He was abnormally bright mentally, discussing metaphysical and spiritual subjects. He was strongly group-conscious and only happy when sharing what he had with others. After his arrival at the clinic, he rapidly grew worse and died in a month. An autopsy showed a tumor of the pineal gland.

Pineal gland is one of so called chakras in mystic teachings and it is known that pineal gland is involved with altered states of consciousness [**?**]. Meditation practices assign to third-eye meditation development of "light in the original cavity or center of spirit" located in the center of the brain and "waking of Kundalini" is associated to pineal gland [**?**].

The fractal hierarchy of the magnetic flux tubes corresponds to a hierarchy of selves and pineal gland is known to contain magnetic crystals. These crystals create magnetic fields which are much weaker than Earth's magnetic field. Their flux tubes, with thickness measured in centimeters, could thus be carriers of super-conducting BE condensates with cyclotron time scale measured in the range year–thousand years. These higher level magnetic selves together with corresponding MEs could be responsible for the higher levels of the self hierarchy. One could perhaps understand also the various characteristics of near death experiences in terms of higher level magnetic consciousness [K20]. Thus Descartes could have been right after all!

7.5 Great Vision About Biological Evolution And Evolution Of Brain

7.6 Great Vision About Biological Evolution And Evolution Of Brain

The following great vision about evolution and is not perhaps strictly about hierarchy of EEGs. The hierarchy of dark matter and EEGs however leads to this vision naturally. The first part of vision relates to biological evolution. Second part is about the evolution of brain. Here the key thread is evolution of two kinds of intelligences, the ordinary fast intelligence evolving via the emergence of fast computation type activities and emotional slow intelligence developing via the emergence of higher levels of dark matter hierarchy. The latter intelligence is what distinguishes us from animals.

7.6.1 Basic Assumptions

The great vision about evolution and brain relies on two several new notions and ideas.

1. Life as something in the intersection of real and p-adic worlds making possible negentropic entanglement- both space-like and time-like. This makes possible to understand what conscious intelligence is and NMP reduces evolution to a generation of negentropic entanglement (see **Fig.** `http://tgdtheory.fi/appfigures/cat.jpg` or **Fig. ??** in the appendix of this book). DNA as topological quantum computer hypothesis [K2] finds also a justification.

2. The notion of many-sheeted space-time (see **Fig.** `http://tgdtheory.fi/appfigures/manysheeted.jpg` or **Fig.** 9 in the appendix of this book) suggesting a universal hierarchy of metabolic energy quanta, and the notion of magnetic body.

3. Communication and control based on Josephson radiation and cyclotron transitions crucial for understanding bio-photons and EEG and its fractal generalization as a key element of bio-communications.

4. Zero energy ontology and the closely related notion of causal diamond (CD) assigning a hierarchy of macroscopic time scales to elementary particles coming as octaves of the basic time scale and justifying p-adic length scale hypothesis. Zero energy energy ontology also justifies the vision about memory and intentional action and the idea that motor action can be seen as time reversal of sensory perception.

5. The hierarchy of Planck constants and the identification of the fundamental evolutionary step as an increase of Planck constant. Evolutionary steps mean migration to the pages of the Big Book labeled by larger values of Planck constant and living system can be regarded as a collection of pages of the Big Book such that a transfer of matter and energy between the pages is taking place all the time. The change of the Planck constant implies either reduction or increase of the quantum scales-this leads to a model for biocatalysis and a model of cognitive representations as scaled down or scaled up "stories" mimicking the real time evolution.

6. A resonant like interaction between hierarchy of Planck constants and p-adic length scale hierarchy favoring the values of Planck constant proportional to powers of two, and idea that weak and color interactions are especially important in the length scales which correspond to Mersenne primes and Gaussian Mersennes. The simplest option is that weak bosons have their standard masses but appear as massless below their Compton length which scales up like $\hbar$ and preferred p-adic length scales correspond to Mersenne primes. Also copies of weak bosons and gluons with ordinary value of Planck constant and reduced mass scale can (and will) be considered.

How to identify the preferred values of Planck constant?

The basic problem is to identify the preferred values of Planck constant and here one can only make theoretical experimentation and all what follows must be taken in this spirit. One can consider assumptions which become increasingly stronger.

1. If only singular coverings of CD and CP_2 are possible Planck constant is a product of integers. Algebraic simplicity of algebraic extensions of rationals favors ruler and compass integers (Appendix).

2. A resonant interaction between the dark length scales and p-adic length scales with ordinary value of Planck constant favors Planck constants coming as powers of two.

3. An even stronger assumption would be that p-adic length scales coming as Mersennes and Gaussian Mersennes are especially interesting.

   (a) If weak bosons can appear with the ordinary value of Planck constant only in the p-adic length scale $k = 89$, one obtains the condition

   $$k_d = k - 89 \ , \ \ k \in \{89, 107, 113, 127, 151, 157, 163, 167\} \tag{7.6.1}$$

   for the values of of $r = 2^{k_d}$ allowing dark weak bosons in p-adic length scales assignable to Mersennes. These values of k_d assign to electrons and quarks dark p-adic length scales $L(k_{eff}) = \sqrt{r}L(k)$, $r \equiv \hbar/\hbar_0 = 2^{k_d}$. The scales could correspond to size scales of basic units of living systems.

   (b) If weak bosons and possibily also gluons with ordinary value of Planck constant are possible in all p-adic length scales $L(k)$, $k \in \{89, 107, 113, 127, 151, 157, 163, 167\}$, one obtains much richer structure. This hierarchy defines defines secondary dark matter hierarchies from the condition that the scaling the p-adic length scale $L(k_1)$ in this set by $\sqrt{r}$, $r \equiv \hbar/\hbar_0 = 2^{k_d}$, gives a p-adic length scale equal to another p-adic length scale $L(k_2)$ in this set. This requires $k_d + k_1 = k_2$ so that the values

   $$k_d = k_2 - k_1 \tag{7.6.2}$$

   are favored for the scaling of $\hbar$. In this case the hierarchy of dark scales assignable to quarks and leptons is much richer. The tables below demonstrate that electron appears as its dark variant for all Mersennes and also in atomic length scales $k = 137, 139$ so that this option puts electron in a completely unique position.

4. Also other scales are possible. For instance, $r = 2^{47}$ required by 5 Hz Josephson frequency gives dark weak scale which corresponds $k = 136$ as a p-adic scale. The stages of sleep can be understood in terms of scaling of $\hbar$ by factor 2 and 4 so that also the atomic length scale $k = 137$ and the scale $k = 138$ are involved.

Since the experimental input is rather meager, one is forced to do theoretical experimentation with various hypothesis. The quantitative experimental tests are rather primitive but basically quantal.

1. The time scales assignable to CDs of leptons and quarks and their scaled up counterparts for the preferred values of Planck constant should define biologically important time scales. One might even speak about evolutionary level of electron. These time scales could define fundamental biorhythms and also time scales of long term memory and planned action.

k_d	p_1	p_2		k_d	p_1	p_2
4	163	167		38	**89**	127
6	107	113		38	113	151
6	151	157		40	127	167
6	157	163		44	107	151
10	157	167		44	113	157
12	151	163		50	107	157
14	113	127		50	113	163
16	151	167		54	113	167
18	**89**	107		56	107	163
20	107	127		60	107	167
24	**89**	113		62	**89**	151
24	127	151		68	**89**	157
30	127	157		74	**89**	163
36	127	163		78	**89**	167

Table 7.2: The integers k_d characterizing the preferred values of $r = \hbar/\hbar_0 = 2^{k_d}$ identified from the condition that the dark variant of p-adic length scale $L(p_1)$ corresponding to some ordinary p-adic length scale defined by Mersenne prime M_p or Gaussian Mersenne $M_{G,p}$, $p \in \{89, 107, 113, 127, 151, 157, 163, 167\}$ corresponds to similar p-adic length scale $L(p_2)$. If one assumes that weak bosons can appear with ordinary value of Planck constant only in the p-adic length scale $k = 89$, only the rows with $p_1 = 89$ of the table are possible: in these cases p_1 is in boldface and the row has double underline. The corresponding values of k_d are in the set $\{18, 24, 38, 62, 68, 74, 78\}$.

2. Josephson frequencies and cyclotron frequencies scaling like $1/\hbar$ (if magnetic field scales down like $1/\hbar$) charactering biologically important ions and elementary particles. In accordance with the quantum criticality of living matter it is assumed that cell membrane corresponds to almost vacuum extremal so that classical Z^0 force is an essential element of the model. Also these frequencies should define fundamental bio-rhythms and characterize the evolutionary level of cell. Experimentally of special importance are the cyclotron frequencies assignable to Ca^{++} ions.

3. The amplitude windows for electric field scaling like $\hbar$ for a particular cyclotron frequency define a basic prediction.

Tables about predicted time and length scales

The following tables summarize various predictions for time scales and length scales. They correspond to the most general assumption that exotic bosons with the ordinary value of Planck constant are possible in all length scales associated with Mersennes and Gaussian Mersennes.

Note that **Table 7.2** includes only the dark length scales associated with $k = 89$ gauge bosons.

Electron and u quark are different

Before continuing an important observation is in order. Electron is exceptional when compared to quarks. It appears as a dark particle in all p-adic length scales defined by biologically important Gaussian Mersennes and also in atomic length scales $k = 137$ and $k = 139$. The reason is trivial: by the basic assumptions electron must appear at same length scales as weak bosons above $k = 127$ since it corresponds to Mersenne prime. Also for the less general option (exotic intermediate gauge bosons are possible only as the dark variants of the standard ones) it appears at cell membrane length scale $k = 151$, which is due to the fact that one has $113 - 89 = 151 - 127 = 24$. Also u quark can appear with $k_{eff} = 137, 139, 163, 167$ and also this is an accident. The light invariants of intermediate gauge bosons appearing in long p-adic length scales would naturally correspond to

Z, W	d	u	e	k_d
89	120	124	127	**0**
93	124	127	131	4
95	126	129	133	6
99	130	133	137	10
101	132	135	139	12
103	134	137	141	14
105	136	139	143	16
107	138	141	145	**18**
109	140	143	147	20
113	144	147	151	**24**
119	150	153	157	30
125	156	159	163	36
127	158	161	165	**38**
129	160	163	167	40
133	164	167	171	44
139	170	173	177	50
143	174	177	181	54
145	176	179	183	56
149	180	183	187	60
151	182	185	189	**62**
157	188	191	195	**68**
163	194	197	201	**74**
167	198	201	205	**78**

Table 7.3: The dark p-adic length scales $\sqrt{r}L(k) = L(k_{eff})$, $k_{eff} = k + k_d$, of intermediate gauge bosons Z, W, d and u quarks, and electron for the values $r = 2^{k_d}$ of Planck constant defined in **Table 7.2**. The uppermost row gives the integers characterizing the p-adic length scales of the particles for the standard value of Planck constant. k_{eff} characterizes also the CD times scale through the formula $T(CD, k_{eff}) = 2^{k_{eff}-127} \times .1$ seconds. The rows which correspond to the less general option for which only M_{89} corresponds to weak bosons with ordinary value of Planck constants have double underline and the corresponding values of k_d are in boldface.

k_1	k_M		k_1	k_M		k_1	k_M		k_1	k_M
113	89		113	107		163	127		163	157
127	89		119	107		167	127		169	157
151	89		123	107		133	127		173	157
157	89		113	107		139	127		163	157
163	89		117	107		143	127		167	157
167	89		111	107		133	127		161	157
95	89		175	113		137	127		169	163
109	89		181	113		131	127		183	163
133	89		187	113		225	151		207	163
139	89		191	113		229	151		213	163
145	89		119	113		157	151		219	163
149	89		133	113		171	151		223	163
103	89		157	113		195	151		177	163
127	89		163	113		201	151		201	163
133	89		169	113		207	151		207	163
139	89		173	113		211	151		213	163
143	89		127	113		165	151		217	163
113	89		151	113		189	151		187	163
119	89		157	113		195	151		193	163
125	89		163	113		201	151		199	163
129	89		167	113		205	151		203	163
95	89		137	113		175	151		169	163
101	89		143	113		181	151		175	163
105	89		149	113		187	151		179	163
95	89		153	113		191	151		169	163
99	89		119	113		157	151		173	163
93	89		125	113		163	151		167	163
145	107		129	113		167	151		187	167
169	107		119	113		157	151		211	167
175	107		123	113		161	151		217	167
181	107		117	113		155	151		223	167
185	107		195	127		235	157		227	167
113	107		201	127		163	157		181	167
127	107		205	127		177	157		205	167
151	107		133	127		201	157		211	167
157	107		147	127		207	157		217	167
163	107		171	127		213	157		221	167
167	107		177	127		217	157		191	167
121	107		183	127		171	157		197	167
145	107		187	127		195	157		203	167
151	107		141	127		201	157		207	167
157	107		165	127		207	157		173	167
161	107		171	127		211	157		179	167
131	107		177	127		181	157		183	167
137	107		181	127		187	157		173	167
143	107		151	127		193	157		177	167
147	107		157	127		197	157		171	167

Table 7.4: Table gives all weak boson length scales -both non-dark and dark implied by the assumption that all Mersennes primes and their Gaussian counterparts and their dark counterparts defined $k_d = k_i - k_j$ them are possible.

particle	Z, W	d	u	e
k	89	120	123	127
f(CD)/Hz	2.7488×10^{12}	1280	160	10

Table 7.5: The fundamental frequencies associated with the CDs of intermediate gauge bosons Z, W, d and u quarks, and electron. Note that for intermediate gauge bosons the frequency of CDs corresponds to energy $E = 1.13 \times 10^{-2}$ eV and wavelength $\lambda = 1.01 \times 10^{-4}$ m (size of a large neuron).

Z, W	d	u	e	k_d
3.64e-13	7.81e-04	6.25e-03	1.00e-01	**0**
5.821e-12	1.25e-02	1.00e-01	1.60e+00	4
2.31e-11	5.00e-02	4.00e-01	6.40e+00	6
3.73e-10	8.00e-01	6.40e+00	1.02e+02	10
1.49e-09	3.20e+00	2.56e+01	4.10e+02	12
5.97e-09	1.28e+01	1.02e+02	1.65e+03	14
2.38e-08	5.12e+01	4.10e+02	6.55e+03	16
9.54e-08	2.05e+02	1.64e+03	2.62e+04	**18**
3.81e-07	8.19e+02	6.55e+03	1.05e+05	20
6.10e-06	1.31e+04	1.05e+05	1.68e+06	**24**
3.91e-04	8.39e+05	6.71e+06	1.07e+08	30
2.50e-02	5.37e+07	4.30e+08	6.87e+09	36
1.00e-01	2.15e+08	1.72e+09	2.75e+10	**38**
4.00e-01	8.59e+08	6.87e+09	1.10e+11	40
6.40e+00	1.37e+10	1.10e+11	1.76e+12	44
4.10e+02	8.80e+11	7.04e+12	1.12e+14	50
6.55e+03	1.41e+13	1.13e+14	1.80e+15	54
2.62e+04	5.63e+13	4.50e+14	7.21e+15	56
4.19e+05	9.01e+14	7.21e+15	1.15e+17	60
1.68e+06	3.60e+15	2.88e+16	4.61e+17	**62**
1.07e+08	2.31e+17	1.84e+18	2.95e+19	**64**
6.87e+09	1.48e+19	1.18e+20	1.89e+21	**74**
1.10e+11	2.36e+20	1.89e+21	3.02e+22	**78**

Table 7.6: The $\hbar$-scaled fundamental time scales $T(CD, k_{eff}) = 2^{k_{eff}-127} \times .1$ seconds associated with the CDs of intermediate gauge bosons Z, W, d and u quarks, and electron for the values $\hbar/\hbar_0 = 2^{k_d}$ of Planck constant defined in **Table 7.2**. The scales are expressed in seconds. The uppermost row gives the time scales of CDs for the standard value of Planck constant. The rows which correspond to the less general option for which only M_{89} corresponds to weak bosons with ordinary value of Planck constants have double underline and the corresponding values of k_d are in boldface.

almost vacuum extremals making possible the criticality as the basic aspect of life. One must of course be very cautious about the masses of exotic counterparts of u and d quark: one can also consider the possibility that masses are identical.

7.6.2 Dark Matter Hierarchy And Big Leaps In Evolution

Dark matter hierarchy leads to an amazingly concrete picture about evolutionary hierarchy allowing to identify the counterparts for concepts like mineral, plant, and animal kingdom that we learned during schooldays and ceased to take seriously as students of theoretical physics as we learned that other sciences are just taxonomy. Even more, a view about what distinguishes between prokaryotes, eukaryotes, animal cells, neurons, EEG, and even about what makes cultural evolution, becomes possible. This view is also very useful when one tries to understand the role of microtubules.

The appearance of CDs scaled up in size by $r = \hbar/\hbar_0$ and space-time sheets scaled up in size by $\sqrt{r}$ means the emergence of new levels of structure and it is natural to identify big leaps in evolution in terms of emergence of new larger matter carrying space-time sheet magnetic flux sheets and corresponding magnetic bodies. If magnetic flux quanta are scaled by r magnetic flux quantization conditions remain unaffected if magnetic field strengths scale down by $1/r$ so that the energies of cyclotron photons are not affected. The thickness of flux tubes can remain unchanged if the currents running at the boundaries of the flux quantum cancel the magnetic flux. As already found, this mechanism must be at work inside living organisms wheras in far away region flux quanta are scaled up in size.

The attractive hypothesis is that the leaps in evolution correspond to the emergence of dark variants of weak and possibly also color interactions in dark p-adic length scales which correspond to ordinary p-adic length scales characterized by Mersenne primes. These leaps would be quantum leaps but in different sense as thought usually. The emergence of higher dark matter levels would basically mean the integration of existing structures to larger structures. A good metaphor are text lines at the pages of book formed by magnetic flux sheets whose width is scaled up by r as the new level of dark matter hierarchy emerges. The big leaps can occur both at the level of organism and population and organisms with rather low individual dark matter level can form societies with high dark matter levels and high collective intelligence (honeybees and ants are good example in this respect).

Certainly also other scalings of Planck constant than those summarized in tables are possible but these scalings are of primary interest. This intuition is supported by the observation that electron is completely exceptional in this framework. Electron's dark p-adic length scales corresponds to p-adic length scales $L(k)$, $k = 167, 169$, assignable to atomic and molecular physics and to the Gaussian Mersennes $M_{G,k} = (1+i)^k - 1$, $k \in \{151, 157, 163, 167\}$, assignable to the length scale range between cell membrane thickness 10 nm and nucleus size 2.58 μm. The corresponding p-adic length scales or corresponding electronic Compton lengths, the number of which is 23, are excellent candidates for the scales of basic building brickes of living matter and vary from electron's p-adic length scale up to 1.25 m ($k = 167$ defining the largest Gaussian Mersenne in cell length scale range) and defining the size scale of human body. The corresponding p-adic time scales are also highly interesting and vary from.1 seconds for electron defining the fundamental biorhythm to 9.6×10^{14} years which is by 4-5 orders longer than the age of the observed Universe. For $k = 167$ the time scale is 1.1×10^{11} years and is by one order of magnitude longer than the age of the observed Universe estimated to be 1.37×10^{10} years [E1].

This conceptual framework gives rather strong guidelines for the identification of the levels of evolutionary hierarchy in terms of dark matter hierarchy. The outcome is a more detailed vision about big evolutionary leaps. Note that in the sequel only the general option is considered: the justification for this is that for this option electron appears as a dark particle for all length scales defined by Gaussian Mersennes as well as in atomic length scales. The basic vision in nutshell is that evolution means the emergence of dark weak and gluonic physics in both dark and ordinary length scales and that the size scales of the basic biostructures correspond to Mersenne primes and their Gaussian variants.

A sketch about basic steps in evolution

The vision about evolution depends on what one assumes about the initial state.

1. If one assumes that weak bosons with ordinary value of Planck constant were present in the begining, evolution would mean a steady growth of k_d. The problem is that small values of $k_d = k_1 - k_2$ correspond to the Gaussian Mersennes defining cellular length scales. If these exotic weak physics were present from the beginning, large parity breaking in cellular length scales would have been present all the time.

2. An alternative and perhaps more realistic view is that the evolution means the emergence of exotic weak physics corresponding almost vacuum extremals in increasingly longer length scales. A possible mechanism could have been the induction of exotic $\hbar_0$ variant of weak physics at the nearest Mersenne length scale k_{next} by the dark variant of weak physics at level k so that one would have $k_d = k_{next} - k$. The simplest induction sequence would have been $89 \to 107 \to 113 \to 127 \to 151 \to 157 \to 163 \to 167$ corresponding to $k_d \in \{18, 6, 14, 24, 6, 6, 4\}$. A possible interpretation of exotic $\hbar_0$ physics is in terms of almost vacuum extremals and non-standard value of Weinberg angle: also weak bosons of this physics would be light. This sequence defines the minimal values for k_d but also larger values of k_d are possible and would correspond to steps between neighbours which are not nearest ones.

The following sketch about the basic steps of evolution relies on the latter option.

1. Elementary particle level

Magnetic bodies with size scale defined by the sizes of CDs assignable to quarks and leptons and possibly also weak bosons (already now the size of big neuron emerges) corresponds to the lowest level of hierarchy with the sizes of the basic material structures corresponding to the Compton lengths of elementary particles. The fundamental bio-rhythms corresponding to frequencies 10, 160, and 1280 Hz appear already at this level in zero energy ontology which suggests that elementary particles play a central and hitherto unknown role in the functioning of living matter.

2. $89 \to 107$ *step with* $k_d = 18$

The first step would have been the emergence of $k_{eff} = 107$ weak bosons inducing $\hbar_0$ weak physics in $k = 107$ length scale characterizing also ordinary hadrons. This in turn would have led to the emergence of exotic nucleons possibly corresponding to almost vacuum extremals. The reduction of the model for the vertebrate genetic code to dark hadron physics [K108] is one of the most unexpected predictions of quantum TGD and assumes the existence of exotic- possibly dark- nucleons whose states with a given charge correspond to DNA, RNA, mRNA, and tRNA. The $\hbar_0$ variants of these nucleons would interact via weak bosons with hadronic mass scale. The exotic variants of the ordinary $k = 113$ nuclei would correspond to the nuclear strings consisting of exotic nucleons [K30, K108] and define nuclear counterparts for DNA sequences. Their dark counterparts could define counterparts of DNA sequences in atomic physics length scales. Therefore a justification for the previous observation that genetic code could be realized at the level of hadron physics and that chemical realization would be higher level realization finds justification. The anomalous properties of water could be also partly due to the presence of dark nucleons and the proposal was that the presence of exotic nuclei is involved with water memory [K49]. The possible existence of the analog of DNA-RNA transcription between ordinary DNA and its nuclear counterpart would have dramatic implications. For instance, one can imagine a mechanism of homeopathy based on this kind of transription process which would also allow a modification of genome by using dark nuclei to communicate the DNA sequences through the cell membrane to the target nuclei.

3. $107 \to 113$ *step with* $k_d = 6$

The next step would have been the emergence of $k_{eff} = 113$ weak bosons inducing $\hbar_0$ weak physics in $k = 113$ length scale characterizing also ordinary hadrons. Exotic variants of the ordinary nuclei possibly corresponding to almost vacuum extremals could have emerged interacting weakly (or actually relatively strongly!) via the exchange of weak bosons with mass scale of order 100 MeV. Also dark variants of the exotic $k = 107$ nucleons could have have emerged and formed exotic nuclei of size scale $k = 119$.

4. $113 \to 127$ *step with* $k_d = 14$

At this step weak bosons in electron mass scale would have emerged. Whether these weak bosons could have induced large parity breakings in atomic and molecular length scales is not clear. Viruses, which do not yet possess cell membrane could correspond to this level of hierarchy.

5. $127 \to 151$ *step with* $k_d = 24$

This step would have been fundamental since weak bosons in cell membrane length scale would have appeared. Note that by $113 - 89 = 24$ this step also leads from $k = 89$ weak bosons to $k = 113$ weak bosons. The weak bosons assignal to $k = 151$ could correspond to the weak interactions associated with almost vacuum extremals and $sin^2(\theta_W) = .0295$ could correspond to the weak physics in question.

$k_d = 24$ step for $k = 113$ $\hbar_0$ weak bosons would have produced them in $k_{eff} = 137$ atomic length scale with $L(137) \simeq .78$ Angstrom This could have naturally led to large parity breaking effects and chiral selection.

Dark $k_{eff} = 151$ electrons appearing in the TGD inspired model of high T_c super-conductivity would have been a by-product of this step. Whether dark electrons could have transformed to light $\hbar_0$ electrons (of mass.25 keV) with a common mass scale of order 10^2 eV with exotic weak bosons is an interesting question. The model of high T_c super-conductivity predicts the presence of structures analogous to cell membrane. This would suggest that cell membranes emerged and chiral selection emerged at this step so that one could not distinguish the emergence of molecular life as a precedessor for the emergence of cell membrane like structures. This would conform with the fact that DNA molecules are stable only inside cell nucleus. Note that for $k_{eff} = 151$ electron's CD has time scale $2^{24} \times .1$ seconds -that is 19.419 days (day=24 hours).

The smallest nanobes [I4] appearing in rocks have size 20 nm and could have emerged at this step. The size of the viruses [I8] is between 10-300 nm covers the entire range of length scales assignable to Gaussian Mersennes, which suggests that smallest viruses could have emerged at this step. Also the smallest [I3] [I3], which by definition have size smaller than 300 nm could have appeared at this stage.

6. The remaining steps

The remaining steps $k = 151 \to 157 \to 163 \to 167$ could relate to the emergence of coiling structure DNA and other structures inside cell nucleus. $k = 167$ would correspond to $k_d = 167 - 89 = 68$ to be compared with the value $k_d = 47$ required by 5 Hz Josephson frequency for the neuronal membrane for -70 mV resting potential. Note that $k_d = 48$ (state 1-2 of deep sleep) corresponds to $k = 163$.

By their smallness also double and triple steps defined by $k_d = k_{i+n} - k_i$, $n > 1$, are expected to be probable. As a consequence, electrons can appear as dark electrons at all the Gaussian Mersenne levels. At these steps the dark electrons corresponding to primes $k_{eff} = 137, 139$ would appear. For $k = 137$ dark electron appears with CD time scale equal to 128 seconds- rather precisely two minutes. The model for EEG suggests that the exotic weak bosons appear in the scales $k_{eff} = 136, 137, 138$.

Further multisteps from the lower levels of hierarchy would give structures with size scales above the size of cell nucleus possibly assignable to organs and structural units of brain. The dark levels assignable to electron are expected to be of special interest. It is encouraging that the longest scale assignable to electron in this manner corresponds to $k = 205$ and length scale of 1.28 m defining body size. As a consequence dark electrons are predicted at levels $k = 137, 139, 141, 143, 145, 147$ coming as octaves.

Prokaryotic cells (bacteria, archea) without cell nucleus for which cell membrane is responsible for metabolic functions and genome is scattered around the cell could have emerged at this step. This would mean that the emergence of the cell membrane thickness as a fundamental scale is not enough: also the size scale of membrane must appear as p-adic length scale. The sizes of most prokaryotes vary between 1 μm and 10 μm: the lower bound would require $k = 163$. There also prokaryotes with sizes between.2 μm ($k = 157$ corresponds to.08 μm) and 750 μm. Cell nuclei, mitochondria, and other membrane bounded cell nuclei would have evolved from prokaryotes in this framework. The sizes of eukaryote cells are above 10 μm and the fact that multicellular organisms are in question strongly suggests that the higher multisteps giving rise to weak bosons and dark electrons in length scales above $L(167)$ are responsible for multi-cellular structures.

This scenario leaves a lot of questions unanswered. In particular, one should understand

in more detail the weak physics at various length scales as well as various exotic nuclear physics defined by dark nucleons and dark variants of nuclei.

Division of the evolution to that of biological body and magnetic body

Electron's Mersenne prime M_{127} is the highest Mersenne prime, which does not correspond to a completely super-astrophysical p-adic length scale. In the case of Gaussian Mersennes $M_{G,k}$ one has besides those defined by k in $\{113, 151, 157, 163, 167, \}$ also the ones defined by k in $\{239, 241, 283, 353, 367, 379, \ 457, 997\}$ [A1]. The appropriately extended model for evolution allows to distinguish between three kinds of values of k_{eff}.

1. The values of k_{eff} for which electron can appear as dark particle and thus satisfying $k_{eff} \leq 205$ (Table 5). These levels would correspond to structures with size below 1.25 m defined roughly by human body size and it is natural to assign the evolution of super-nuclear structures to the levels $167 < k_{eff} \leq 205$.

2. The values of of k_{eff} for which dark gauge bosons are possible in the model. This gives the condition $k_{eff} \leq 235$. These levels correspond to structures in the range 1.25 m-40 km. The identification as parts of the magnetic body can be considered.

3. The values of k_{eff} obtained by adding to the system also the Gaussian Mersenne pair $k \in \{239, 241\}$ allowing also the dark electrons. The lower size scale for these structures is 640 km.

4. The higher levels corresponding to k_{eff} in $\{283, 353, 367, ...\}$. The lower size scale for these structures is 3 AU (AU is the distance from Earth to Sun).

$k_{eff} > 205$ levels would correspond to the emergence of structures having typically size larger than that of the biological body and not directly visible as biological evolution. This evolution could be hidden neuronal evolution meaning the emergence of extremely low Josephson frequencies of the neurons modulating higher frequency patterns and being also responsible for the communication of long term memories.

Biological evolution

In principle the proposed model allowing multisteps between hierarchy levels defined by Mersenne primes and their Gaussian counterparts could explain the size scales of the basic structures below the size scale 1.25 m identified in terms of the $k_{eff} \leq 205$ levels of the hierarchy.

1. The emergence of cells having organelles

The appearance of the structures with $k_{eff} > 167$ (possibly idetifiable as magnetic body parts) should correlate with the emergence of simple eukaryotic cells and organisms, in particular plant cells for which size is larger than 10 μm, which could correspond to $k_{eff} = 171$ for electron and dark variants of weak gauge bosons. $k_{eff} = 177$ is the next dark electron level and corresponds to 80 μm scale. It seems natural to assume that these dark weak bosons do not transform to their $\hbar_0$ counterparts at these space-time sheets.

Cell nucleus would be the brain of the cell, mitochondria would be the energy plant, and centrioles generating microtubules would define the logistic system. Also other organelles such as Golgi apparatus, ribosomes, lysosomes, endoplasmic reticulum, and vacuoles would be present. These organelles would live in symbiosis by topologically condensing to $k_{eff} \geq 171$ magnetic body controlling their collective behavior. Centrosomes associated with animal cells would not be present yet but microtubule organizing centers would already be there.

The recent observations show that centrioles are not always in the characteristic T shaped conformation. Daughter centrioles resulting during the replication of mother centriole use first ours of their lifetime to roam around the cell before becoming mature to replicate. A possible interpretation is that they are also life forms and that magnetic body utilizes daughter centrioles to perform some control functions crucial for the future development of the cell. For instance, centrioles visit the place where axonal growth in neurons starts.

Cytoskeleton would act as a counterpart of a central nervous system besides being responsible for various logistic functions such as transfer of proteins along microtobuli. Centrioles give also rise to basal bodies and corresponding cilia/flagella used by simple cells to move or control movement of air or liquid past them. Centriole pair would be also used by the magnetic body to control cell division.

The logistic functions are the most obvious functions of microtubules. Magnetic body would control cell membrane via signals sent through the cell nucleus and communicated to the cell membrane along microtubuli. Basal bodies below the cell membrane and corresponding cilia/flagella would serve as motor organs making possible cell motion. Tubulin conformations representing bits would allow microtubule surface to represent the instructions of the magnetic body communicated via via cell nucleus to various proteins moving along the microtubular surface so that they could perform their functions.

TGD based view about long memory recall as communication with geometric past allows also the realization of cellular declarative memories in terms of the conformational patterns. Memory recall corresponds to a communication with geometric past using phase conjugate bosons with negative energies reflected back as positive energy bosons and thus representing an "image" of microtubular conformation just like ordinary reflected light represents ordinary physical object. There would be no need for a static memory storage which in TGD framework would mean taking again and again a new copy of the same file.

Receptor proteins would communicate cell level sensory input to the magnetic body via MEs parallel to magnetic flux tubes connecting them to the magnetic body. We ourselves would be in an abstract sense fractally scaled up counterparts of receptor proteins and associated with dark matter iono-lito Josephson junction connecting the parts of magnetosphere below litosphere and above magnetosphere. The communication would be based on Josephson radiation consisting of photons, weak bosons, and gluons defining the counterpart of EEG associated with the level of the dark matter hierarchy in question.

3. The emergence of organs and animals

The emergence of magnetic bodies with k_{eff} in the range $(177, 181, 183, 187, 189, 195, 201, 205)$ allowing both dark electron and weak bosons could accompany the emergence of multicellular animals. Magnetic body at this level could give rise to super-genome making possible genetic coding of organs not yet possessed by plant cells separated by walls from each other. The super structures formed from centrosomes and corresponding microtubuli make possible complex patterns of motion requiring quantum coherence in the scale of organs as well as memories about them at the level of organs.

4. The emergence of nervous system

k_{eff} in the range $(187, 189, 195, 201, 205)$ allowing dark electrons and weak bosons gives size scales $(.25, .5, 4, 32, 128)$ cm, which could correspond to the scales of basic units of central nervous system. What would be of special interest would be the possibility of charged entanglement based on classical W fields in macroscopic length scales. The emergence of the new level means also the integration of axonal microtobuli to "text lines" at the magnetic flux sheets making possible logistic control at the multineuronal level. The conformational patterns of the microtubular surface would code nerve pulse patterns to bit patterns representing declarative long term memories. An interesting question is whether the reverse coding occurs during memory recall.

The evolution of magnetic body

For mammals with body size below 1.25 m the levels $k_{eff} > 205$ cannot correspond to biological body and the identification in terms of magnetic body is suggestive. The identification of EEG in terms of Josephson frequencies suggests the assignment of EEG with these levels.

1. The emergence of EEG

EEG in the standard sense of the word is possessed only by vertebrates and one should understand why this is the case. The value of Josephson frequency equal to 5 Hz requires only $k_d = 47$ so that something else must be involved. A possible explanation in the framework of the proposed model comes from the following observations.

1. Besides the maximal p-adic scale $k = 205$ for which electron and weak bosons appears as dark variants the model allows also levels at which only gauge bosons appear as dark particles. From **Table 7.6**one finds that levels $k \in \{207, 211, 213, 217, 219, 221, 223, 225, 229, 235\}$ are allowed. Could it be that these levels and possibly some highest levels containing both electrons and gauge bosons as dark particles are a prerequisite for EEG as we define it. Its variants at higher frequency scales would be present also for invertebrates. The lowest Josephson frequency coded by the largest value of $\hbar$ in the cell membrane system determines the Josephson frequency.

2. The membrane potentials -55 mV (criticality against firing) correspond to ionic Josephson energies somewhat above 2 eV energy ((2.20, 2.74, 3.07, 2.31) eV, see Table 1). For 2 eV the wavelength 620 nm is near to $L(163) = 640$ nm. Therefore the Josephson energies of ions can correspond to the $L_e(k = 163)$ if one assumes that a given p-adic mass scale corresponds to masses half octave above the p-adic mass scale so that the opposite would hold true at space-time level by Uncertainty Principle. Josephson frequencies $f_J \in \{5, 10, 20, 40, 80, 160\}$ Hz correspond to $k_d \in \{47, 46, 45, 44, 43, 42\}$ giving $k_{eff} \in \{210, 209, 208, 207, 206, 205\}$.

   (a) Cerebellar resonance frequency 160 Hz would correspond to $k = 205$ -the highest level for for which model allows dark electrons (also 200 Hz resonance frequency can be understood since several ions are involved and membrane potential can vary).

   (b) The 80 Hz resonance frequency of retina would correspond to $k_{eff} = 206$ -for this level dark electrons would not be present anymore.

   (c) 40 Hz thalamocortical frequency would correspond to $k_{eff} = 207$.

   (d) For EKG frequencies are EEG frequencies below 20 Hz 12.5 and heart beat corresponds to .6-1.2 second cycle (the average.8 s corresponds to $k_{eff} = 212$).

3. Even values of k_{eff} are not predicted by the model based on Mersenne primes allowing only odd values of k_{eff} so that the model does not seem to be the whole truth. The conclusion which however suggests itself strongly is that EEG and its variants identified as something in the range 1-100 Hz, are associated with the levels in at which only dark weak bosons are possible in the proposed model. Note that the size scales involved with EEG would be above the size scale of human body so that we would have some kind of continuation of the biological body to be distinguished from the magnetic body. The time scales assignable to the dark CDs would be huge: for instance, $k = 205$ would correspond to $T = 2^{42} \times .1$s making about 1395 years for electron.

2. Does magnetic body correspond to the space-time sheets carrying dark weak bosons?

The layers of the magnetic body relevant for EEG have have size of order Earth size. Natural time scale for the moment of sensory consciousness is measured as a fraction of second and the basic building blocks of our sensory experience corresponds to a fundamental period of.1 seconds. This scale appears already at $\hbar_0$ level for electron CD. The natural question concerns the relationship of the magnetic body to the $k > 205$ space-time sheets carrying only gauge bosons in the model and having size scale larger than that of biological body. Do they correspond to an extension of biological body or should they be regarded as parts of the magnetic body? The following observations suggest that they could correspond to layers of the magnetic body responsible for the fractal variant of EEG.

1. The primary p-adic time scales (Compton times) $T(239)$ and $T(241)$ correspond to frequencies, which are $2^{\pm 1/2}$ kHz. The geometric average $k = 240$ corresponds to kHz frequency. Is the appearance of kHz scale a mere accident or do the frequencies assignable to the quark CDs correspond to Compton times $\propto \sqrt{2^{k_{eff}/2}}$?

2. One can apply scalings by 2^{k_d} to the triplet $(239, 240, 241)$ to get a triplet $(239 + k_d, 240 + k_d, 241 + k_d)$. The results are summarized in **Table 11.4**. Clearly the frequencies in question cover also the EEG range. Note that these frequencies scale as $\sqrt{1/r}$ whereas Josephson frequencies scale as $1/r$.

k_d	f_1/Hz	f_2/Hz	f_3/Hz
0	707	1000	1412
4	177	250	354
6	89	1250	177
10	22.1	31.3	44.2
12	11.1	15.6	22.1
14	5.5	7.8	11.1
16	2.8	3.9	5.5
18	1.4	2.0	2.8
20	0.7	1.0	1.4
24	0.2	0.2	0.3

Table 7.7: The Compton frequencies obtained by scaling $2^{k_d/2}$ from the basic triplet $k_{eff} = (239, 240, 241)$. The values of k_d correspond to those predicted by the model based on Mersenne primes.

Also ZEG and WEG would appear but in much shorter scales dictated by k_{eff} and might accompany EEG. Somehow it seems that the effective masslessness of weak bosons below given scale is highly relevant for life. One can of course ask whether some larger Gaussian Mersenne could change the situation. There is a large gap in the distribution of Gaussian Mersennes after $k = 167$ and the next ones correspond to $M_{G,k}$, with k in $(239, 241, 283, 353, 367, 379, 457, 997)$ [A1]. The twin pair $k = (239, 241)$ corresponds to a length scales $(1.6, 3.2) \times 10^2$ km and the minimum value for k_d are (72, 74) ($167 \to (239, 241)$ transition).

3. Long term memory and ultralow Josephson frequencies

What determines the time scale associated with long term memory is a crucial question if one really wants to understand the basic aspects of consciousness.

1. Does the time scale correspond to the size scale of CD assignable to electron scaled by $r = \hbar/\hbar_0$? In this case relatively small values of r would be enough and $r = 2^{47}$ would give time scale of 10^{13} s for for electron's CD, which is about 3×10^5 years. This does not make sense.

2. Does Josephson frequency define the relevant time scale? In this case the long term memory would require the analog of EEG in the time scale of memory span. $k_{eff} = 205$ would give 6 ms time scale for memory from the assignment of $k_{eff} = 163$ to the Josephson photons at V=-50 mV implying $k_d = 42$. Minute scale would require $k_{eff} = 217$. The highest level $k_{eff} = 235$ allowed by the model involving only Gaussian Mersennes with $k \leq 167$ would correspond to a time scale of 77.67 days (day is 24 hours). For Gaussian Mersennes defined by $k_{eff} = (239, 241)$ the time scales become about (41.4, 82.8) months (3.4 and 6.8 years). These scales should also define important biorhythms. The claimed 7 years rhythm of human life could relate to the latter rhythm: note that the precise value of the period depends on the membrane potential and thus varies. The presence of the scaled up variants of the by $k_d \leq 78$ allows longer time spans of long term memory and the scaling defined by $k_d = 167 - 163 = 4$ scales up the span of long term memories to (54.4, 108.8) years.

4. Cultural evolution

Higher levels in the hierarchy would correspond mostly to the evolution of hyper-genome coding for culture and social structures. Introns are good candidate for the nucleotides involved. The development of speech faculty is certainly a necessary prerequisite for this breakthrough. Already EEG seems to correspond to dark layers of biological body larger than biological body so that one can cask whether the weak bosons and dark electrons in the length scales $k = 239, 241, 283, 353, 367, ...$ could be relevant for the collective aspect of consciousness and cultural evolution. Maybe the size scales $(175, 330)$ km and their scaled up variants by $k_d \leq 78$ might

have something to do with the spatial scale of some typical social structure (not city: the area of New York is only 790 km^2).

7.7 Appendix

7.7.1 Hierarchy Of Planck Constants And The Generalization Of The Notion Of Embedding Space

In the following the recent view about structure of embedding space forced by the quantization of Planck constant is summarized. The question is whether it might be possible in some sense to replace H or its Cartesian factors by their necessarily singular multiple coverings and factor spaces. One can consider two options: either M^4 or the causal diamond CD. The latter one is the more plausible option from the point of view of WCW geometry.

The evolution of physical ideas about hierarchy of Planck constants

The evolution of the physical ideas related to the hierarchy of Planck constants and dark matter as a hierarchy of phases of matter with non-standard value of Planck constants was much faster than the evolution of mathematical ideas and quite a number of applications have been developed during last five years [K91, K71, K40]

1. The starting point was the proposal of Nottale [E2] that the orbits of the 4 inner planets correspond to Bohr orbits with Planck constant $\hbar_{gr} = GMm/v_0$ and outer planets with Planck constant $\hbar_{gr} = 5GMm/v_0$, $v_0/c \simeq 2^{-11}$. The basic proposal [K91, K71] was that ordinary matter condenses around dark matter which is a phase of matter characterized by a non-standard value of Planck constant whose value is gigantic for the space-time sheets mediating gravitational interaction. The interpretation of these space-time sheets could be as magnetic flux quanta or as massless extremals assignable to gravitons.

2. Ordinary particles possibly residing at these space-time sheet have enormous value of Compton length meaning that the density of matter at these space-time sheets must be very slowly varying. The string tension of string like objects implies effective negative pressure characterizing dark energy so that the interpretation in terms of dark energy might make sense [K92]. TGD predicted a one-parameter family of Robertson-Walker cosmologies with critical or over-critical mass density and the "pressure" associated with these cosmologies is negative.

3. The quantization of Planck constant does not make sense unless one modifies the view about standard space-time is. Particles with different Planck constant must belong to different worlds in the sense local interactions of particles with different values of $\hbar$ are not possible. This inspires the idea about the book like structure of the embedding space obtained by gluing almost copies of H together along common "back" and partially labeled by different values of Planck constant.

4. Darkness is a relative notion in this framework and due to the fact that particles at different pages of the book like structure cannot appear in the same vertex of the generalized Feynman diagram. The phase transitions in which partonic 2-surface X^2 during its travel along X^3_l leaks to another page of book are however possible and change Planck constant. Particle (say photon -) exchanges of this kind allow particles at different pages to interact. The interactions are strongly constrained by charge fractionization and are essentially phase transitions involving many particles. Classical interactions are also possible. It might be that we are actually observing dark matter via classical fields all the time and perhaps have even photographed it [K107].

5. The realization that non-standard values of Planck constant give rise to charge and spin fractionization and anyonization led to the precise identification of the prerequisites of anyonic phase. If the partonic 2-surface, which can have even astrophysical size, surrounds the tip of CD, the matter at the surface is anyonic and particles are confined at this surface. Dark matter could be confined inside this kind of light-like 3-surfaces around which ordinary matter

condenses. If the radii of the basic pieces of these nearly spherical anyonic surfaces - glued to a connected structure by flux tubes mediating gravitational interaction - are given by Bohr rules, the findings of Nottale [E2] can be understood. Dark matter would resemble to a high degree matter in black holes replaced in TGD framework by light-like partonic 2-surfaces with a minimum size of order Schwartschild radius r_S of order scaled up Planck length $l_{Pl} = \sqrt{\hbar_{gr} G} = GM$. Black hole entropy is inversely proportional to $\hbar$ and predicted to be of order unity so that dramatic modification of the picture about black holes is implied.

6. Perhaps the most fascinating applications are in biology. The anomalous behavior ionic currents through cell membrane (low dissipation, quantal character, no change when the membrane is replaced with artificial one) has a natural explanation in terms of dark supra currents. This leads to a vision about how dark matter and phase transitions changing the value of Planck constant could relate to the basic functions of cell, functioning of DNA and amino-acids, and to the mysteries of bio-catalysis. This leads also a model for EEG interpreted as a communication and control tool of magnetic body containing dark matter and using biological body as motor instrument and sensory receptor. One especially amazing outcome is the emergence of genetic code of vertebrates from the model of dark nuclei as nuclear strings [L4, K107], [L4].

The most general option for the generalized embedding space

Simple physical arguments pose constraints on the choice of the most general form of the embedding space.

1. The fundamental group of the space for which one constructs a non-singular covering space or factor space should be non-trivial. This is certainly not possible for M^4, CD, CP_2, or H. One can however construct singular covering spaces. The fixing of the quantization axes implies a selection of the sub-space $H_4 = M^2 \times S^2 \subset M^4 \times CP_2$, where S^2 is geodesic sphere of CP_2. $\hat{M}^4 = M^4 \backslash M^2$ and $\hat{CP}_2 = CP_2 \backslash S^2$ have fundamental group Z since the codimension of the excluded sub-manifold is equal to two and homotopically the situation is like that for a punctured plane. The exclusion of these sub-manifolds defined by the choice of quantization axes could naturally give rise to the desired situation.

2. CP_2 allows two geodesic spheres which left invariant by $U(2$ *resp.* $SO(3)$. The first one is homologically non-trivial. For homologically non-trivial geodesic sphere $H_4 = M^2 \times S^2$ represents a straight cosmic string which is non-vacuum extremal of Kähler action (not necessarily preferred extremal). One can argue that the many-valuedness of $\hbar$ is un-acceptable for non-vacuum extremals so that only homologically trivial geodesic sphere S^2 would be acceptable. One could go even further. If the extremals in $M^2 \times CP_2$ can be preferred non-vacuum extremals, the singular coverings of M^4 are not possible. Therefore only the singular coverings and factor spaces of CP_2 over the homologically trivial geodesic sphere S^2 would be possible. This however looks a non-physical outcome.

   (a) The situation changes if the extremals of type $M^2 \times Y^2$, Y^2 a holomorphic surface of CP_3, fail to be hyperquaternionic. The tangent space M^2 represents hypercomplex sub-space and the product of the Kähler-Dirac gamma matrices associated with the tangent spaces of Y^2 should belong to M^2 algebra. This need not be the case in general.

   (b) The situation changes also if one reinterprets the gluing procedure by introducing scaled up coordinates for M^4 so that metric is continuous at $M^2 \times CP_2$ but CDs with different size have different sizes differing by the ratio of Planck constants and would thus have only piece of lower or upper boundary in common.

3. For the more general option one would have four different options corresponding to the Cartesian products of singular coverings and factor spaces. These options can be denoted by $C-C$, $C-F$, $F-C$, and $F-F$, where C (F) signifies for covering (factor space) and first (second) letter signifies for CD (CP_2) and correspond to the spaces $(\hat{CD} \hat{\times} G_a) \times (\hat{CP}_2 \hat{\times} G_b)$, $(\hat{CD} \hat{\times} G_a) \times \hat{CP}_2/G_b$, $\hat{CD}/G_a \times (\hat{CP}_2 \hat{\times} G_b)$, and $\hat{CD}/G_a \times \hat{CP}_2/G_b$.

4. The groups G_i could correspond to cyclic groups Z_n. One can also consider an extension by replacing M^2 and S^2 with its orbit under more general group G (say tetrahedral, octahedral, or icosahedral group). One expects that the discrete subgroups of $SU(2)$ emerge naturally in this framework if one allows the action of these groups on the singular sub-manifolds M^2 or S^2. This would replace the singular manifold with a set of its rotated copies in the case that the subgroups have genuinely 3-dimensional action (the subgroups which corresponds to exceptional groups in the ADE correspondence). For instance, in the case of M^2 the quantization axes for angular momentum would be replaced by the set of quantization axes going through the vertices of tetrahedron, octahedron, or icosahedron. This would bring non-commutative homotopy groups into the picture in a natural manner.

About the phase transitions changing Planck constant

There are several non-trivial questions related to the details of the gluing procedure and phase transition as motion of partonic 2-surface from one sector of the embedding space to another one.

1. How the gluing of copies of embedding space at $M^2 \times CP_2$ takes place? It would seem that the covariant metric of CD factor proportional to $\hbar^2$ must be discontinuous at the singular manifold since only in this manner the idea about different scaling factor of CD metric can make sense. On the other hand, one can always scale the M^4 coordinates so that the metric is continuous but the sizes of CDs with different Planck constants differ by the ratio of the Planck constants.

2. One might worry whether the phase transition changing Planck constant means an instantaneous change of the size of partonic 2-surface in M^4 degrees of freedom. This is not the case. Light-likeness in $M^2 \times S^2$ makes sense only for surfaces $X^1 \times D^2 \subset M^2 \times S^2$, where X^1 is light-like geodesic. The requirement that the partonic 2-surface X^2 moving from one sector of H to another one is light-like at $M^2 \times S^2$ irrespective of the value of Planck constant requires that X^2 has single point of M^2 as M^2 projection. Hence no sudden change of the size X^2 occurs.

3. A natural question is whether the phase transition changing the value of Planck constant can occur purely classically or whether it is analogous to quantum tunnelling. Classical non-vacuum extremals of Chern-Simons action have two-dimensional CP_2 projection to homologically non-trivial geodesic sphere S^2_I. The deformation of the entire S^2_I to homologically trivial geodesic sphere S^2_{II} is not possible so that only combinations of partonic 2-surfaces with vanishing total homology charge (Kähler magnetic charge) can in principle move from sector to another one, and this process involves fusion of these 2-surfaces such that CP_2 projection becomes single homologically trivial 2-surface. A piece of a non-trivial geodesic sphere S^2_I of CP_2 can be deformed to that of S^2_{II} using 2-dimensional homotopy flattening the piece of S^2 to curve. If this homotopy cannot be chosen to be light-like, the phase transitions changing Planck constant take place only via quantum tunnelling. Obviously the notions of light-like homotopies (cobordisms) are very relevant for the understanding of phase transitions changing Planck constant.

How could one fix the spectrum of Planck constants?

The question how the observed Planck constant relates to the integers n_a and n_b defining the covering and factors spaces, is far from trivial and I have considered several options. The basic physical inputs are the condition that scaling of Planck constant must correspond to the scaling of the metric of CD (that is Compton lengths) on one hand and the scaling of the gauge coupling strength $g^2/4\pi\hbar$ on the other hand.

1. One can assign to Planck constant to both CD and CP_2 by assuming that it appears in the commutation relations of corresponding symmetry algebras. Algebraist would argue that Planck constants $\hbar(CD)$ and $\hbar(CP_2)$ must define a homomorphism respecting multiplication and division (when possible) by G_i. This requires $r(X) = \hbar(X)\hbar_0 = n$ for covering and $r(X) = 1/n$ for factor space or vice versa.

2. If one assumes that $\hbar^2(X)$, $X = M^4$, CP_2 corresponds to the scaling of the covariant metric tensor g_{ij} and performs an over-all scaling of H-metric allowed by the Weyl invariance of Kähler action by dividing metric with $\hbar^2(CP_2)$, one obtains the scaling of M^4 covariant metric by $r^2 \equiv \hbar^2/\hbar_0^2 = \hbar^2(M^4)/\hbar^2(CP_2)$ whereas CP_2 metric is not scaled at all.

3. The condition that $\hbar$ scales as n_a is guaranteed if one has $\hbar(CD) = n_a\hbar_0$. This does not fix the dependence of $\hbar(CP_2)$ on n_b and one could have $\hbar(CP_2) = n_b\hbar_0$ or $\hbar(CP_2) = \hbar_0/n_b$. The intuitive picture is that n_b- fold covering gives in good approximation rise to n_an_b sheets and multiplies YM action action by n_an_b which is equivalent with the $\hbar = n_an_b\hbar_0$ if one effectively compresses the covering to $CD \times CP_2$. One would have $\hbar(CP_2) = \hbar_0/n_b$ and $\hbar = n_an_b\hbar_0$. Note that the descriptions using ordinary Planck constant and coverings and scaled Planck constant but contracting the covering would be alternative descriptions.

   This gives the following formulas $r \equiv \hbar/\hbar_0 = r(M^4)/r(CP_2)$ in various cases.

	$C-C$	$F-C$	$C-F$	$F-F$
r	n_an_b	$\frac{n_a}{n_b}$	$\frac{n_b}{n_a}$	$\frac{1}{n_an_b}$

Preferred values of Planck constants

Number theoretic considerations favor the hypothesis that the integers corresponding to Fermat polygons constructible using only ruler and compass and given as products $n_F = 2^k \prod_s F_s$, where $F_s = 2^{2^s} + 1$ are distinct Fermat primes, are favored. The reason would be that quantum phase $q = exp(i\pi/n)$ is in this case expressible using only iterated square root operation by starting from rationals. The known Fermat primes correspond to $s = 0, 1, 2, 3, 4$ so that the hypothesis is very strong and predicts that p-adic length scales have satellite length scales given as multiples of n_F of fundamental p-adic length scale. $n_F = 2^{11}$ corresponds in TGD framework to a fundamental constant expressible as a combination of Kähler coupling strength, CP_2 radius and Planck length appearing in the expression for the tension of cosmic strings, and I have considered the possibility that the powers of 2^{11} are favored as values of n_a in living matter.

How Planck constants are visible in Kähler action?

$\hbar(M^4)$ and $\hbar(CP_2)$ appear in the commutation and anti-commutation relations of various super-conformal algebras. Only the ratio of M^4 and CP_2 Planck constants appears in Kähler action and is due to the fact that the M^4 and CP_2 metrics of the embedding space sector with given values of Planck constants are proportional to the corresponding Planck constants [K40]. This implies that Kähler function codes for radiative corrections to the classical action, which makes possible to consider the possibility that higher order radiative corrections to functional integral vanish as one might expect at quantum criticality. For a given p-adic length scale space-time sheets with all allowed values of Planck constants are possible. Hence the spectrum of quantum critical fluctuations could in the ideal case correspond to the spectrum of $\hbar$ coding for the scaled up values of Compton lengths and other quantal lengths and times. If so, large $\hbar$ phases could be crucial for understanding of quantum critical superconductors, in particular high T_c superconductors.

Do factor spaces and coverings correspond to the two kinds of Jones inclusions?

What could be the interpretation of these two kinds of spaces?

1. Jones inclusions appear in two varieties corresponding to $\mathcal{M} : \mathcal{N} < 4$ and $\mathcal{M} : \mathcal{N} = 4$ and one can assign a hierarchy of subgroups of $SU(2)$ with both of them. In particular, their maximal Abelian subgroups Z_n label these inclusions. The interpretation of Z_n as invariance group is natural for $\mathcal{M} : \mathcal{N} < 4$ and it naturally corresponds to the coset spaces. For $\mathcal{M} : \mathcal{N} = 4$ the interpretation of Z_n has remained open. Obviously the interpretation of Z_n as the homology group defining covering would be natural.

2. $\mathcal{M} : \mathcal{N} = 4$ should correspond to the allowance of cosmic strings and other analogous objects. Does the introduction of the covering spaces bring in cosmic strings in some controlled

manner? Formally the subgroup of $SU(2)$ defining the inclusion is $SU(2)$ would mean that states are $SU(2)$ singlets which is something non-physical. For covering spaces one would however obtain the degrees of freedom associated with the discrete fiber and the degrees of freedom in question would not disappear completely and would be characterized by the discrete subgroup of $SU(2)$.

For anyons the non-trivial homotopy of plane brings in non-trivial connection with a flat curvature and the non-trivial dynamics of topological QFTs. Also now one might expect similar non-trivial contribution to appear in the spinor connection of $\hat{M}^2\hat{\times}G_a$ and $\hat{CP}_2\hat{\times}G_b$. In conformal field theory models non-trivial monodromy would correspond to the presence of punctures in plane.

3. For factor spaces the unit for quantum numbers like orbital angular momentum is multiplied by n_a *resp.* n_b and for coverings it is divided by this number. These two kind of spaces are in a well defined sense obtained by multiplying and dividing the factors of $\hat{H}$ by G_a *resp.* G_b and multiplication and division are expected to relate to Jones inclusions with $\mathcal{M} : \mathcal{N} < 4$ and $\mathcal{M} : \mathcal{N} = 4$, which both are labelled by a subset of discrete subgroups of SU(2).

4. The discrete subgroups of $SU(2)$ with fixed quantization axes possess a well defined multiplication with product defined as the group generated by forming all possible products of group elements as elements of $SU(2)$. This product is commutative and all elements are idempotent and thus analogous to projectors. Trivial group G_1, two-element group G_2 consisting of reflection and identity, the cyclic groups Z_p, p prime, and tetrahedral, octahedral, and icosahedral groups are the generators of this algebra.

   By commutativity one can regard this algebra as an 11-dimensional module having natural numbers as coefficients ("rig"). The trivial group G_1, two-element group G_2¡ generated by reflection, and tetrahedral, octahedral, and icosahedral groups define 5 generating elements for this algebra. The products of groups other than trivial group define 10 units for this algebra so that there are 11 units altogether. The groups Z_p generate a structure analogous to natural numbers acting as analog of coefficients of this structure. Clearly, one has effectively 11-dimensional commutative algebra in 1-1 correspondence with the 11-dimensional "half-lattice" N^{11} (N denotes natural numbers). Leaving away reflections, one obtains N^7. The projector representation suggests a connection with Jones inclusions. An interesting question concerns the possible Jones inclusions assignable to the subgroups containing infinitely manner elements. Reader has of course already asked whether dimensions 11, 7 and their difference 4 might relate somehow to the mathematical structures of M-theory with 7 compactified dimensions. One could introduce generalized WCW spinor fields in the WCW labelled by sectors of H with given quantization axes. By introducing Fourier transform in N^{11} one would formally obtain an infinite-component field in 11-D space.

5. How do the Planck constants associated with factors and coverings relate? One might argue that Planck constant defines a homomorphism respecting the multiplication and division (when possible) by G_i. If so, then Planck constant in units of $\hbar_0$ would be equal to n_a/n_b for $\hat{H}/G_a \times G_b$ option and n_b/n_a for $\hat{H}\hat{\times}(G_a \times G_b)$ with obvious formulas for hybrid cases. This option would put M^4 and CP_2 in a very symmetric role and allow much more flexibility in the identification of symmetries associated with large Planck constant phases.

7.7.2 Em Cyclotron Frequencies Of Biologically Important Ions

A detailed study of the cyclotron frequencies demonstrates that they indeed seem to correspond to important EEG frequencies. The cyclotron frequencies associated with other singly ionized atoms can be obtained by the formula

$$f = \frac{A}{20} \times f(Ca^{2+}) \qquad f(Ca^{2+}) \simeq 15\ Hz\ . \tag{7.7.1}$$

Here the strength of the magnetic field is assumed to be $B_{end} = .2$ Gauss $= 2 \times 10^{-5}$ Tesla. Note that published material there was an erratic identification $B = B_E = .5$ Gauss due to the calculational error.

Elementary particle	f_1/Hz	J	f_L/Hz
e	5.6×10^5	1/2	2.8×10^5
p	300	1/2	419
Bosonic ions			
^6Li	50.1	1	88.3
O^{2-}	37.4	0	0
Mg^{++}	25.0	0	0
Ca^{++}	15.0	0	0
Mn^{2+}	11.4	5/2	520
Fe^{2+}	10.8	0	0
Co^{2+}	10.0	7/2	695
Zn^{2+}	9.4	0	0
Se^{2-}	7.6	0	0
Fermionic ions			
$^7Li^+$	42.9	3/2	489
N^+	21.4	1	60.6
F^-	15.8	1/2	395
Na^+	13.0	3/2	333
Al^+	11.1	5/2	546
Si^+	10.7	0	0
P^+	9.7	1/2	170
S^-	9.4	0	0
Cl^-	8.5	3/2	130
K^+	7.5	3/2	58.5
Cr^-	5.7	3/2	71.1
Cu^+	4.8	3/2	333.9
Ag^+	2.8	1/2	17
I^+	2.4	5/2	420
Au^+	1.5	3/2	21

Table 7.8: The first column gives cyclotron frequency in cycles per second for some ions in Earth's magnetic field assumed to have strength $B_{end} = .2 \times 10^{-4}$ Tesla. The remaining columns give spin or nuclear spin and Larmor frequency f_L.

Table 7.8 lists cyclotron frequencies and their lowest multiples for some of the most important ions.

7.7.3 Cyclotron Frequencies Of Exotic Ions And Periodic Table

Exotic em and Z^0 ions result when some color bonds in atomic nucleus become charged and are simultaneously ordinary ions. By magnetic flux quantization Z^0 magnetic cyclotron frequencies differ from their electromagnetic counterparts for singly charged ions only by charge ratio factors $Q_Z/Q_{Z,0}$. Hence it is convenient to represent electromagnetic cyclotron frequencies instead. The ions in various periods correspond to bands of EEG: it seems however that satellites of the harmonics of cyclotron frequencies beta and theta bands and that harmonics of frequencies in alpha band provides a more natural explanation for gamma and higher bands. For completeness cyclotron frequencies for all periods are given although the biologically important heavy ions are rather scarce.

Ions in Helium period correspond to beta and gamma bands

Table 7.9 lists the relevant data about ions in He period. Cyclotron frequencies are in the range $(15.8 - 75)$ Hz for nuclear exotic ionization which respects statistics. Note that Be and N atoms

Ion	(Z, A, S)	f_1/Hz	Ion	(Z, A, S)	f_1/Hz
He	(2, 4, F)	75	C	(6, 12, F)	25.0
Li	(3, 7, F)	42.9	N	(7, 14, B)	21.4
Be	(4, 9, B)	33.3	O	(8, 16, F)	18.8
B	(5, 11, F)	27.3	F	(9, 19, F)	15.8

Table 7.9: Basic data for the ions in Helium period. Cyclotron frequency and nuclear spin for exotic ion with unit electric charge due to the charged color bond in nucleus. F or B tells the statistics of the electronically ionized atom (most atoms are bosons in ground state).

Ion	(Z, A, S)	f_1/Hz	Ion	(Z, A, S)	f_1/Hz
Ne	(10, 20, F)	15.0	Si	(14, 28, F)	10.7
Na	(11, 23, F)	13.0	P	(15, 31, F)	9.7
Mg	(12, 24, F)	12.5	S	(16, 32, F)	9.4
Al	(13, 27, F)	11.1	Cl	(17, 35, F)	8.5

Table 7.10: One can arrange the exotic ions in Neon period to one triplet of exotic ions allowing also spin flip qualia and to a quintet assigned with cyclotron qualia. For the meanings of various notations see previous table.

are exceptional being fermions in ground state. Li ion has rather high cyclotron frequency 42.9 Hz.

Ions in Neon period correspond to alpha band

For Neon period nuclear exotic ionization the frequencies span the range $8.5 - 15.0$ Hz: only 15 Hz cyclotron frequency of Ne belongs to beta band.

Ions in Argon period correspond to theta band

Singly ionized exotic ions in Argon period have cyclotron frequencies in the range ($3.6\ Hz < f \leq 7.5\ Hz$).

Ions in Krypton period correspond to delta band

Krypton period provides an almost identical copy of Argon period. The cyclotron frequencies of Krypton band are in the range $2.3 - 3.5$ Hz.

Ion	(Z, A, S)	f_1/Hz	Ion	(Z, A, S)	f_1/Hz
Ar	(18, 40, F)	7.5	Co	(27, 59, F)	5.0
K	(19, 39, F)	7.5	Ni	(28, 58, F)	5.2
Ca	(20, 40, F)	7.5	Cu	(29, 63, F)	4.8
Sc	(21, 45, F)	6.7	Zn	(30, 64, F)	4.7
Ti	(22, 48, F)	6.3	Ga	(31, 69, F)	4.3
V	(23, 51, F)	5.9	Ge	(32, 74, F)	4.1
Cr	(24, 52, F)	5.7	As	(33, 75, F)	4.0
Mn	(25, 55, F)	5.5	Se	(34, 80, F)	3.8
Fe	(26, 56, F)	5.4	Br	(35, 79, F)	3.8

Table 7.11: Basic data for singly charged exotic ions with frequencies in Argon period and having cyclotron frequencies in theta band.

Ion	(Z, A, S)	f_1/Hz	Ion	(Z, A, S)	f_1/Hz
Kr	(36, 84, F)	3.6	Rh	(45, 103, F)	2.9
Rb	(37, 85, F)	3.5	Pd	(46, 108, F)	2.8
Sr	(38, 86, F)	3.5	CD	(48, 114, F)	2.6
Y	(39, 89, F)	3.4	Ag	(47, 107, F)	2.8
Zr	(40, 90, F)	3.3	In	(49, 115, F)	2.6
Nb	(41, 93, F)	3.2	Sn	(50, 120, F)	2.5
Mo	(42, 98, F)	3.0	Sb	(51, 121, F)	2.5
Tc	(43, 99, F)	3.0	Te	(52, 130, F)	2.3
Ru	(44, 102, F)	2.9	I	(53, 127, F)	2.4

Table 7.12: Table 15. Basic data for singly charged exotic ions having [Kr] as ground state configuration. Tc does not allow stable isotopes but the lifetimes of two long-lived Tc isotopes are 1.5×10^6 years and 2.1×10^5 years.

Ion	(Z, A, S)	f_1/Hz	Ion	(Z, A, S)	f_1/Hz
Xe	(54, 132, F)	2.3	Yb	(70, 174, F)	1.7
Cs	(55, 133, F)	2.3	Lu	(71, 176, B)	1.7
Ba	(56, 138, F)	2.2	Hf	(72, 178, F)	1.7
La	(57, 139, F)	2.2	Ta	(73, 181, F)	1.7
Ce	(58, 140, F)	2.1	W	(74, 184, F)	1.6
Pr	(59, 141, F)	2.1	Re	(75, 187, F)	1.6
Nd	(60, 142, F)	2.1	Os	(76, 192, F)	1.6
Pm	(61, 147, F)	2.0	Ir	(77, 193, F)	1.6
Sm	(62, 152, F)	2.3	Pt	(78, 195, B)	1.5
Eu	(63, 154, B)	1.9	Au	(79, 197, F)	1.5
Gd	(64, 158, F)	2.0	Hg	(80, 202, F)	1.5
Tb	(65, 160, F)	1.9	Ti	(81, 205, F)	1.5
Dy	(66, 164, F)	1.8	Pb	(82, 206, F)	1.5
Ho	(67, 165, F)	1.8	Bi	(83, 209, F)	1.4
Er	(68, 166, F)	1.8	Po	(84, 209, F)	1.4
Tm	(69, ?, ?)	?	At	(85, 211, F)	1.4

Table 7.13: Basic data for ions with having [Xe] as ground state configuration.

Basic data for Xenon period

Table 7.13 lists ions with [Xe] ground state. Note that all ions in Xe band do not have stable isotopes and it is questionable whether any biologically interesting ions are in this period. Cyclotron frequencies of singly charged exotic ions in Xenon period vary in the range $1.5 - 2.2$ Hz.

Chapter 8

Quantum Model for EEG

8.1 Introduction

In previous chapter the overall TGD based view about EEG was discussed. According to this view, the basic function of EEG is to induce cyclotron phase transitions at the magnetic body and thus allows magnetic body to share the standarded mental images produced by brain via negentropic quantum entanglement. Magnetic body would also produce what might be called higher level sensory qualia identified as emotions and cognitions. In this chapter the relationship between EEG and nerve pulse patterns is discussed in TGD framework.

8.1.1 Vision About Eeg

The general model for EEG relies on the idea that EEG frequencies correspond to Josephson frequencies defined by membrane potentials and provide cognitive and one might also say emotional representation of the sensory input at the magnetic body in terms of cyclotron transitions. The perturbations of the membrane potentials caused by spikes, neurotransmitters affecting alertness reducing the magnitude of the resting potential induced frequency modulations of the membrane potentials and one can say that the cell is like a singing whale with evoked potentials and nerve pulse patterns coded to the varying frequency. Song is expression of this singing but also speech involves frequency modulation as one learns by playing slowly recorded spoken language.

The scale of the frequency assignable to a given neuron is determined by the value 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-adically scaled up electronic Compton length scales 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 [K38].

This proposal will be referred to as Mersenne hypothesis and it leads to strong predictions about EEG since it predicts a spectrum of preferred Josephson frequencies for a given value of membrane potential and also assigns to given value of $\hbar$ a fixed size scale having interpretations as size scale of body part or magnetic body.

An essential assumption is that cell membrane corresponds to almost vacuum extremal so that classical Z^0 field proportional to em field is present and leads to the replacement of ionic

charges with effective charges much larger than ionic charges so that that membrane voltage corresponds to a photon energy in visible or UV range and the energies of biologically most important ions span half octave. From this it follows that for given ion and membrane voltage the value of r fixes completely the Josephson frequency. For instance 5 Hz frequency corresponds to $r = 2^{k_d}$, $k_d = 47$.

Armed with this picture one ends up with a rather detailed quantitative model for EEG discussed already in [K38]. In this chapter this model is applied in more detail. Features, synchronization, stochastic resonance, temporal codings, and what I have used to called scaling will be discussed.

8.1.2 Features

Walter Freeman has identified spatially amplitude modulated synchronous but non-periodic EEG patterns serving as correlates for conscious percepts. The duration of features is in the range 80-120 ms and there is spatial coherence but no strict periodicity but 1 ms temporal resolution so that one can speak of spatial amplitude modulation of a temporal pattern which is same over the spatial cross section of the feature. The basic patterns recur with a period of 5-7 Hz. The sizes of features are in the range 1-2 cm.

The model of EEG and bio-photons in terms of large $\hbar$ Josephson radiation generated by cell membrane Josephson junctions predicts that the wavelength of Josephson photon with energy of visible or UV photon and scaling like $\hbar$ is dictated by the size scale of the structure generating ELF radiation with frequency scaling as $1/\hbar$. This hypothesis combined with the Mersenne hypothesis [K38] allows to build a picture about the values of Planck constant involved with the features. Also the fact the causal diamonds (CDs) of d quark and electron correspond to kHz and 10 Hz frequencies is expected to be relevant for the model.

8.1.3 Synchronization

Synchronization in and between various cortical areas is known to occur with millisecond precision. Also disjoint brain regions can be in synchrony. This is difficult to understand without synchronizing agent oscillating at kHz frequency.

Again kHz frequency brings in mind d quark CD. kHz Josephson frequency is second candidate. If this frequency is also realized as cyclotron frequency identifiable as a scaled up alpha frequency, the value of the magnetic field must be by a factor 2^7 stronger than $B_{end} = .2$ Gauss and thus about 2 mTesla. The model for hearing requires the hierarchy of magnetic field values so that this hypothesis might make sense.

In TGD framework magnetic body and hierarchy of Planck constants inducing the scaling of p-adic length scales is the natural agent inducing the synchrony and MEs could induce the synchronization. Synchronization would naturally occur at the frequency corresponding to a duration of the bit of the memetic code. kHz frequency corresponds to the size scale of head and makes possible the synchronization of cortical areas.

8.1.4 Stochastic Resonance

Concerning the mapping of EEG frequencies to nerve pulse patterns, stochastic resonance promotes itself as a basic mechanism. In bistable systems stochastic resonance allows to amplify very weak periodic signals by utilizing white noise. Stochastic resonance is known to be relevant also at the neuronal level as demonstrated by the autocorrelation functions for spike sequences exhibiting peaks at the harmonics of the signal frequency. Neuron is however far from being bistable system, and this raises the question whether bi-stability might be present at some deeper quantal level.

Nerve pulses generate EEG MEs and the frequency of the nerve pulses determines the rate at which EEG MEs are generated rather than the frequency of EEG MEs. TGD inspired model of nerve pulse assigns to the resting state of cell a propagating soliton sequence and nerve pulse corresponds to a perturbation which locally transformation propagation to oscillations. The states correspond to the states of the bistable system. The system in resting state is near criticality in the sense that rotation velocity is slightly above the minimum one so that reduction of membrane potential transforms rotation motion to oscillatory motion locally. Stochastic resonances makes

itself visible in the autocorrelation function of the spike sequence and in this way also in the membrane potential of say glial cells coupling to neurons. In fact, glial cells could play the role of listener of radio turning the knob (noise level) to tune the neurons to a particular spiking frequency.

8.1.5 Temporal Codings

The conventional view that the information content of conscious experience is determined completely by rate coding from nerve pulse patterns does not seem plausible in TGD framework where massless extremals suggest a coding preserving phase information and based essentially on coherent summation of perturbations of membrane voltages coming from presynaptic neurons. The superposition of contributions to membrane voltage imply interference effects. It is known that spike interval statistics allows to regenerate recognizable speech artificially by stimulating neurons electrically. The destruction of phase information while keeping spike rate as such lhowever eads to a loss of experienced emotional content of artificial spike patterns. This suggests that the interference effects code for the emotional content of nerve pulse pattern and the outcome is cognitive and emotional representation at the magnetic body.

One can consider also cognitive codes for which only spike patterns are significant and analogous to the rhythmic patterns of music. Indeed, p-adic cognitive codes define an entire hierarchy of binary codes associated with the p-adic frequencies and frequency coding would apply only to the average intensity of the sensory input. For high stimulus intensities the duration of the bit of the p-adic cognitive codeword tends to become shorter. This is comparable to the increase of the speech rate during a high state of arousal, and conforms with the observed shift of EEG towards higher frequencies in this kind of situation. There is a lot of experimental evidence supporting the existence of various kinds of temporal codings, and these codings are discussed in TGD framework.

8.1.6 Scaling Law

Scaling law provides bird's eye view about transitions which can represent conscious-to-us qualia at given level of the p-adic self hierarchy. The law relates two levels of self hierarchy corresponding to mental images associated with magnetic bodies of astrophysical size and with physical bodies, the latter with size not much larger than brain size. Scaling law assumes that self sizes L at given p-adic level k are between the p-adic length scales $L(k)$ and $L(k(next))$. Scaling law is of form $L = v/f$ and relates ELF self size characterized by ELF frequency f to the self size L and to the effective phase velocity v of the EEG wave.

Scaling law also suggested by the experimental work with the effects of ELF radiation in water [I16]. As discussed in [K49] scaling law can be explained in terms of phase transitions transforming large $\hbar$ photons to ordinary ones. The chapter ends with the discussion about possible implications of the scaling law concerning EEG.

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` [L14].

8.2 Eeg, Meg, Nerve Pulse And Mini-Potentials

In this section the basic facts about EEG, MEG, nerve pulse and mini-potentials are briefly reviewed.

8.2.1 EEG

E(lectro)E(ncephalo)G(ram) is the study (or graphing) of the electric potential on the surface of the skull [**?**]. EEG waves are oscillations of the membrane potential with frequency varying in the range 1-100 Hz. The amplitude of the oscillating membrane potential is typically 10^{-4} Volts and by a factor 10 smaller than postsynaptic potential. EEG waves is a vertebrate phenomenon, insect ganglia do not exhibit comparable potentials.

Four basic rhythms have been identified in EEG wave spectrum and their amplitude and frequency correlate strongly with the state of awareness [**?**]. It must be emphasized that the

boundaries of frequency ranges vary by few Hz depending on author.
i) α rhythm. f = 8-13 Hz and amplitude is about 20 micro-volts. α dominates in rest but not in the sleep state. A sudden illumination by light leads to the disappearance of the α component of EEG.
ii) β rhythm. f = 14-30 Hz with amplitude about 40-100 micro-volts. β dominates during a conceptual thinking.
iii) γ rhythm. f = 30-90 Hz with. Gamma rhythm is associated with temporal coding of sensory information.
iv) θ rhythm. f = 4-7 Hz. θ dominates during sleeping without dreams. Dreams in turn correspond to β waves.
v) δ rhythm. f = 0.5-3 Hz. δ corresponds to deep sleeping without dreaming.
In general the amplitude is smaller the larger the frequency is.

EEG reflects also alarm reaction and sensory responses. Various mental disorders, brain tumors and brain injuries reflect themselves in EEG. Epilepsy, which corresponds to hyperexcitability of some part of the nervous system induces characteristic changes in the EEG pattern. EEG varies also considerably during the development. EEG appears at the age of year as occasional bursts with frequency 4-8 Hz and the adult form of EEG is established before the age of 19.

The question whether all EEG waves genuinely propagate or not is not resolved experimentally yet. It is known that alpha waves propagate and that the propagation velocity is about $v \sim 10$ m/s. There is also evidence for the propagation of 40 Hz EEG waves [**?**, **?**].

There is no doubt that EEG waves are deeply involved with the basic functioning of the brain but the origin and the exact function of EEG has remained a mystery. The EEG waves associated with two distant neurons are strongly correlated and this supports the view that EEG waves are related to the properties of the brain as a coherent quantum system.

8.2.2 MEG

This subsection gives a brief summary about magnetoencephalography (MEG). The motivation is that brain could act with MEs by acting effectively like magnetometer somewhat in the same way as SQUID magnetometer measures the magnetic fields generated by brain.

SQUIDs

SQUIDs [**?**, **?**, **?**] are instruments used to measure extremely weak magnetic field in the case that the resolution needed is below the magnetic flux quantum $h/2e$ ($\hbar = c = 1$) for magnetic flux in super conductor. An important application of SQUIDs is to the measurement of the weak magnetic fields generated by brain and having strengths as weak as fT. SQUID technology has been used to detect the weak magnetic fields created by brain (10^{-13} Tesla region) and quite an impressive knowledge exists about the magnetic correlates of the brain activity in ELF region [**?**].

A rough description of SQUIDs goes as follows.

1. The current in SQUID measures the deviation of the external magnetic field from a multiple of magnetic flux quanta which is reflected as a presence of a current in SQUID which creates magnetic field compensating this deviation.

2. The circuit equations can be written for the magnetic flux through SQUID and differ from the equations for RCL resonance circuit only by the presence of Josephson current non-linear with respect to the magnetic flux. If the super current is accompanied by a white noise with a correct intensity, SQUID amplifies the periodic signal in resonant manner. The stochastic resonance in SQUIDs has been demonstrated experimentally [**?**].

3. SQUID consists of a closed current loop decomposing to two parts connected by thin non-super-conducting insulators. This makes possible rapid dissipation of the current to the minimal value needed by flux quantization. Small deviations from the quantized flux can be accurately measured by measuring the persistent supra current.

The basic equation governing the behavior of SQUID relies in the following simple model. SQUID is characterized by inductance L relating magnetic flux to current ($\Phi = LI$ modulo integer

number of flux quanta). The potential difference around SQUID is by Faraday's induction law equal to $eV = d\Phi/dt$. SQUID can be regarded as a capacitor (capacitance C) formed by the two halves of SQUID coupled by the insulators to which one can assign internal resistance R. Insulating parts serve as Josephson junctions through which ordinary Ohmic currents run besides the Josephson current depending sinusoidally on the magnetic flux. The equation for the time derivative of the potential difference around the SQUID loop reads as

$$\begin{aligned} LC\frac{d^2\Phi}{dt^2} &= -\tau\frac{d\Phi}{dt} - \Phi - \beta sin(\Phi) - \xi \ , \\ \beta = \frac{Li_c}{\Phi_0} \ &, \quad \tau = \frac{L}{R} \ , \quad \Phi_0 = \frac{\hbar}{2e} \ . \end{aligned} \tag{8.2.1}$$

Here ξ denotes the white noise contribution to the Josephson current. Φ is measured in units of Φ_0 and in the equation above Φ denotes the deviation of Φ from an integer multiple of Φ_0. The equation is obviously invariant under the symmetry $\Phi \to \Phi + n2\pi$. i_c denotes the critical current for which the super current in the circuit becomes dissipative. Usually also an additional external current guaranteeing a slight over-criticality is added. If the inertial term proportional to LC can be made small, the system rapidly dissipates to equilibrium configuration. For small deviations of Φ from a valued corresponding to a quantized magnetic flux system indeed exhibits stochastic resonance [**?**].

Magnetic fields associated with brain activity

SQUIDs (super-conducting quantum interference devices) have made it possible to measure the magnetic fields associated with the brain activity. The magnetic fields accompanying the evoked responses [**?**] and the background activity of brain are in the range $10 - 10^3$ fT, in general below the level of the geomagnetic noise but above the thermal magnetic noise produced by body which is roughly .1 fT. The frequency range is typically between 0-100 Hz in these measurements and corresponds to the frequency range of EEG. alpha rhythm at 10 Hz generates a sharp peak with a peak value about 1-2 pT, which is slightly above the level of the geomagnetic noise. Eyes create static magnetic fields of about 10^{-11} T. Heart creates an oscillatory field with somewhat stronger intensity below 10^{-10} T and with the frequency of heart beat: this field is in the intensity region of the geomagnetic noise having frequencies above .01 Hz. Sensory stimuli generate typically responses with a strength of few hundred fT consisting of oscillations which start few tens of milliseconds after the stimulus and end few hundreds of milliseconds after the beginning of the stimulus (natural time scale is .1 seconds for the duration of the magnetic response.

The simplest model for the magnetic field associated with an evoked response is as being generated by a point like magnetic dipole or a collection of point like magnetic dipoles. This means that the measured fields are essentially superpositions of radiation fields generated by dipoles. It is possible to determine rather accurately the positions of these effective dipoles in brain and thus to localize various brain functions. Also the dependence of the shape of the frequency spectrum on brain function can be studied and the distribution of the net power in a given frequency range as a function of the location can be studied. Often the ratio of the responses before and after stimulus is measured as a function of position near the surface of the skull.

The simplest hypothesis is that far-away radiation fields decompose into MEs propagating in the radial direction. In TGD based model of EEG, brain is in electromagnetic bath provided by "free" ELF MEs moving along the surface of cortex with the velocity of nerve pulse, and generating electromagnetic responses which decompose in far-away region into MEs propagating into the radial directions. In the induction region more complex flux quanta are possible. The criterion for the radiation region reads as $r \geq \sqrt{\lambda L}$ and relates the distance r between observation point and source, the size L of the source region, and the wavelength. For a point like source this criterion holds everywhere.

Dipole approximation is used in the analysis of the data to determine the position of evoked response. If λ corresponds to the wavelength of 10 Hz radiation and L is of order 10 microns, the the criterion for faraway region is roughly $r > 10$ meters and classical radiation fields measured in the region near brain are induction fields. Hence one cannot regard the magnetic fields induced by the brain activity as consisting of MEs in the measurement region. This is of course natural, since in radiation region a lot of information is lost since the system looks point like in this region.

On basis of EEG one can expect that the intensities of the magnetic fields associated with MEs providing the electromagnetic bath for brain are weaker than the intensities of the evoked fields. The intensity of ELF em radiation in delta band, which is of the same order of magnitude as the radiation associated with [F6] [F6], provides the first guess.

8.2.3 Nerve Pulse

Nerve pulse is the tool used by the nerve cells to communicate information to each other [I64], [**?**]. Nerve pulse is generated, when the potential difference through the cell membrane, rest potential, changes from its rest value about of -80 millivolts to about -50 millivolts, the threshold potential: after this the action potential about 40 millivolts is generated and begins to propagate along the axon with approximately constant velocity varying between 1-100 meters.

For resting potential the concentration of Na_+ ions, Ca_{++} and Cl_- concentrations are much larger outside the cell than in its interior whereas K_+ concentration is larger inside the cell. Thus in absence of constraints ($Na_+ - K_+$ pump) forcing membrane potential to its resting value Na_+, Ca_{++} and Cl_- would flow to cell interior: obviously, the flow of first two tends to reduce the resting potential. K_+ in turn would would flow out of cell interior. Nerve pulse is indeed generated when Na_+ conductance increase and Na_+ rush to cell interior, the return to resting state involves temporal flow of K_+ ions to cell exterior.

The generation of the nerve pulse involves the increase of Na and K conductivity through the cell membrane so that a flow of K and Na ions through cell membrane takes place and action potential is generated. The increase of the conductivity is caused by the opening of Na and K channels. According to the classical model of Hogkin and Huxley [I64] the opening of the Na channels involves the participation of three so called m particles and one so called h particle. The rapid increase of Na conductivity is possible to understand only provided the charge of the m particles is -2 and they are electron pairs [I64]. A possible identification is as Cooper pairs.

The axon consists of two kinds of segments. The first segment having typically a length of the order of 10^{-3} meters is surrounded by a myelin shell: in this region no Na and K currents appear. The velocity of the nerve pulse is of the order of 10^2 m/s in these regions. Between the myelinated regions appear unshielded regions, where Na and K flow appears: these have length of order of 10^{-6} meters: velocity is in general smaller in these regions. The function of the unmyelinated regions is probably to refresh the nerve pulse since the dissipation causes the decrease of the height of the pulse during the propagation through the myelinated regions. The completely unshielded propagation is not economical since metabolic energy gets wasted.

Nerve pulse either ends up to a muscle or is transferred to a neighboring cell through a synaptic connection. There are two kinds of synaptic connections. Gap junctions are direct contacts between two cells and the nerve pulse is transferred electrically to the second cell. In chemical synapses the axon is separated from the dendrite of the receiving cell by a synaptic cleft having width of the order of $10^{-8} - 10^{-7}$ meters. The nerve pulse is transferred chemically via the so called synaptic transmitter substance. The nerve pulse generated in the dendrite can be either excitatory or inhibitory depending on whether the sign of the voltage difference is favorable for the generation of the action potential or not. The value of the postsynaptic potential is about 10 millivolts.

Whether the nerve pulse is generated depends on the inputs received by the nerve cell. In neural network models the output is generated provided the sum of the inputs exceeds a certain threshold value. It is not at all clear however whether the inputs correspond to potentials or something else, but closely related to postsynaptic potentials. What seems to be clear is that this quantity can have only two values corresponding to exhibitory and inhibitory inputs respectively. The nerve pulses coming from the sensory organs obey frequency coding. The stronger the sensory input the greater the frequency of the nerve pulses. The duration of the nerve pulse, about few milliseconds, sets of course a limit for the frequency of the pulses.

To summarize, the propagation of the nerve pulse is a well understood process and the interpretation of the action potential as one bit of information is attractive. The idea that nerve pulse is generated, when the sum of inputs (in some sense) exceeds some threshold value seems to be well established. The details related to the generation of the threshold potential and the relationship of the nerve pulse generation to the general state of awareness and memory content

of the brain is however unclear. Also the relationship between nerve pulses and EEG waves is unclear.

8.2.4 Miniature Postsynaptic Potentials

Miniature postsynaptic potentials have quantized amplitude of order .5 mV to be compared with the value of the rest potential, which is roughly 100 times larger [**?**]. Miniature potentials are generated in the postsynaptic neuron, when it has received nerve pulse. The quantized packets of neurotransmitters such as ACh give rise to the emission of miniature potentials. According to [**?**] miniature potentials might consist of superpositions of much smaller micro-potentials of amplitude of order .3 μV generated by single neurotransmitter molecule. One could however consider also the possibility that the minimum size for the quantized packet of neurotransmitter is dictated by the requirement that the packet is able to generate the mini-potential.

8.3 Features And Synchronization

The model for sensory receptor discussed in the previous section is inspired by the general vision for how magnetic body controls biological body and receives information from it. The model generalizes straightforwardly to a model of features. What is new that features would most naturally be induced by W MEs affecting glial cell groups which in turn would induce the synchoronous neuronal firing.

Cyclotron phase transition at appropriate magnetic body induced by cyclotron and Josephson radiation generated by the corresponding biological body defines the feature. Both Josephson and cyclotron frequencies associated with scaled up EEG would scale as $r = \hbar/\hbar_0$. The modulated cyclotron frequency could place code a position of the representation at magnetic body representing some geometric quantity, say the distance of the object of perceptive field. The temporal modulation pattern of the amplitude of cyclotron radiation by some EEG frequency in turn would define the feature assigned at this position. One can distinguish between speech and song like features responsible for cognitive and emotional aspects of perception. Also spatial modulation is present but temporal pattern is same at all points of feature.

Geneticandperhaps even memetic codons with duration of.1 seconds are good candidates for the "phonemes" of speech like features. Recurring feature corresponds to a plasma oscillation with frequency below 10 Hz generated by the charge entanglement by W ME inducing exotic ionization. Ca^{2+}, Mg^{2+} and possibly also other bosonic ion waves are physiological correlates of the features.

1 kHz synchronization frequency reduces in this picture to DNA cyclotron frequency associated with the scaled up variant $\lambda B \simeq .02$ Tesla of the magnetic field $B = B_{end}/2 = .1$ Gauss assignable to the right brain hemisphere and having cyclotron frequency.5 Hz and carrying single flux quantum $h_5 = 5h_0$. Also 2 kHz synchronization frequency is highly suggestive. The dark photons of this radiation could result as DNAs drop to excited cyclotron states at the magnetic flux sheets traversing through the sequences of DNA double strands defining lines of a page of a book represented by the flux sheet. The text line has an interpretation as a supergene expressed collectively during synchronous firing.

Also fractally scaled up variants of features with duration of short term memory and realized as modulations of EEG frequencies are predicted with alpha band taking the role of 1 kHz synchronization. Scaled up variants of memetic/genetic codons would code for information now. In this case the size scale of the features would be $\lambda \times .02 = 40$ m suggesting that collective mental images involving several brains are in question.

8.3.1 Features

The notion of p-adic cognitive representation seems to have an impressive explanatory power. These representations are however local in the spatial degrees of freedom, and the further challenge is to understand how the p-adic codons from various points of cortex are combined to more complex features/symbolic mental images. The work of Freeman with odor perception gives valuable guidelines in this respect [E3]. The findings of Freeman suggest that neurons in a given cortical area define temporally synchronous patterns, features. The temporal synchrony would mean that

all spatial points correspond to the same p-adic codon in the temporal domain. There is however an arbitrary dependence of the feature on the two transversal coordinates of the cortical surface for a given time value. Hence the situation is 3-dimensional but the third dimension is time rather than space.

Features as AM modulated EEG patterns

The coherence lengths for EEG inside cortex are in general much shorter than at the surface of the skull and complex patterns are encountered. In particular, synchronous cortical EEG patterns with coherence length of order 1-2 cm appear (size of Brodmann's areas). Freeman identifies these patterns as basic units, "features", of perceptual activity (the activity related to subjective experience rather than sensory input) [E3], and calls these patterns mesoscopic activity as opposed to the microscopic activity represented by nerve pulse patterns. According to Freeman these patterns are observed besides olfactory bulb also in visual, auditory and somatic cortices.

These synchronous EEG patterns have a non-periodic time dependence which does not depend on position: this would be consistent with the frequency coding of the time span of declarative memory. The amplitude is spatially amplitude modulated. The AM patterns are measured at two-dimensional surface so that the question whether the spatial amplitude modulation is 3-dimensional or 2-dimensional remains open. The patterns are recurring 2-7 times per second, which corresponds to theta band in frequency space. This conforms with the assumption that memories are coded by the same features as direct experiences and that carrier frequency is in theta range unlike for purely symbolic representations of sensory experiences for which it is in gamma range. The duration of the patterns is $T = 80 - 120$ ms.

How to understand the time and length scales associated with the features

The first thing to be understood are the time scales and here TGD inspired model for EEG based on the identification of EEG and bio-photons in terms of Josephson radiation generated by cell membrane acting as Josephson function is the natural starting point. This model is made quantitative by the Mersenne hypothesis to which TGD inspired model of EEG and also biological evolution is based [K38].

1. The time scales bring in mind the causal diamonds (CDs) of d quark and electron with time scales of 100 ms and 1/1.28 ms. For u quark the time scale is 6 ms which corresponds to 160 Hz cerebellar synchrony. What is disturbing is the large relative variation of the durations. These time scales are in rest system of CD and Lorentz transform of CD scales up the time scale. The needed Lorentz boosts look however unrealistic since they would require relativistic velocities for electrons and would explain only the interval 100-120 ms but not 80-100 ms.

2. A more promising hypothesis is that the duration relates to the Josephson frequency of the cell membrane proportional to the resting potential which varies in rather wide limits: -40 mV for visual receptors and -80-90 mV for glial cells. The ratio of the neuron resting potential -70 mV to the critical potential -55 mV for firing and average resting potential -70 mV is 1.2 whereas the ratio for durations is 1.5. The Josephson frequencies of the basic biological ions for almost vacuum extremal cell membrane are modified by the contribution of classical Z^0 field correspond to half octave range and the ratio of maximum to minimum membrane voltage is is quite near to $\sqrt{2} \simeq 1.4$ not too far from 1.5. This option looks the most promising one and would predict a discrete spectrum for the durations smoothed out partially by the variation of the resting potentials.

3. kHz frequency could correspond to Josephson frequency of membrane potential inducing an additive modulation of membrane voltage in turn inducing frequency modulation of Josephson frequencies of in nearby cells. For instance, glial cells could induce this modulation. The model for EEG would suggest that also 5-7 Hz frequency corresponds to a Josephson frequency for cell membrane and thus to $r = \hbar/\hbar_0 = 2^{k_d}$ if one accepts the Mersenne hypothesis to which TGD inspired model of EEG and also biological evolution is based [K38]. This would suggest a hierarchy involving the Josephson frequencies 5-7 Hz, 8.4-12.5 Hz, and 1 kHz.

A three-level hierarchy could be in question with the slowest frequency assignable to hippocampus, next frequency to the higher sensory areas, and kHz frequency possibly to head itself. The identification is supported by internal consistency: kHz frequency defines synchrony in the size scale of entire brain and corresponds to the p-adic length scale assignable to brain. This picture would conform with much more general hypothesis about brain as an orchestra with neurons and glial cells as instruments whose octave is specified by the value of Planck constant restricted by Mersenne hypothesis.

4. The question about interpretation of frequencies assignable to $\hbar_0$ CDs remains. One possibility is that the kHz Josephson radiation with large Planck constant decays to bunches of ordinary kHz quanta as its leaks to $\hbar_0$ page of the Big Book. Other transition would be a transformation to single $\hbar_0$ visible or UV photon having identification as a bio-photon.

One should also understand the size scale of features. Suppose in accordance with Mersenne hypothesis that Josephson wavelength define the structures as scaled up variants of the wave length assignable to $\hbar_0$ Josephson frequencies of basic biological ions, which corresponds to $k_{eff} = 163$ for 2 eV energy. This implies that 5 Hz Josephson frequency corresponds to to $k_{eff} = 210$ - a p-adic length scale, which is roughly 15 meters. 1 cm sized features would correspond to Josephson frequency of about 2×10^5 Hz rather than kHz frequency but one could argue that these features integrate to a larger structure during kHz synchrony making possible binding of mental image in the scale of entire brain. Of course, nothing prevents the presence of also 100 kHz frequency scale and for bats and sea mammals the hearing range extends up to 2×10^5 Hz [**?**, **?**] .

MEs as AM patterns representing features

The identification of massless extremals (MEs) as representations of the features is suggestive since for MEs the time dependence is same for all points in the 2-D transversal cross section. Temporal coherence in turn corresponds to the arbitrary but synchronous dependence of the field pattern on the temporal coordinate at this cross section. Thus MEs are ideal for the communication of the information contained by features to the magnetic body.

MEs allow arbitrary direction and magnitude of transversal polarization and arbitrary time dependence which does not depend on position. 2-dimensional instead of 3-dimensional AM patterns are predicted but this is consistent with empirical data. Note that MEs in question are like light fronts going through the two-dimensional surface where the measurement is performed. One might argue that the character of MEs as topological field quanta of classical radiation means that they are not sufficiently general to model the nearby ELF fields in brain. This might be the case. On the other hand, the solution ansatz defining MEs is extremely general [K70]. In geometric optics picture this means that paths of light rays inside MEs can be also curvilinear light like curves expressible as gradient lines for a Hamilton Jacobi functional S whereas the transverse polarization is defined by a gradient of a polarization function E.

The spectrum of durations for the synchronous time patterns encourages also to consider an interpretation of these patterns as an electromagnetic realization of genetic code words. Also more general p-adic codes can be considered. A compression of the memetic code words defined by the nerve pulse patterns giving rise to abstraction and classification could be in question. The representation would be achieved by the modulation of the alpha waves by higher harmonics of alpha frequencies analogous to ripples. Essentially an interference of slow alpha wave with faster wave containing frequencies up to kHz would be in question.

In the case of hearing the contraction could take place but one can also consider the possibility that entire 126 bit memetic code is realized and that the large number of bits codes for information relation to delicate factors like the emotional coloring of the speech. This would explain the completely exceptional role of the language in cognition.

MEs need not nor cannot be purely electromagnetic and for far from vacuum extremal MEs with vanishing classical Z^0 field classical W fields are necessarily present. W MEs as possible realizers of the generalized motor actions of the magnetic body could induce plasma oscillations and ionic waves define also candidate for the inducers of AM patterns.

Genetic code and odors

The interpretation of AM patterns as sub-selves representing standardized mental images is natural. The average duration of these sub-selves is of 100 ms which is the duration of the memetic codeword [K47]. According to Freeman, the time dependence of AM patterns is chaotic: this does not however mean that it is random. That also time coding is involved looks plausible because both temporal and spatial patterns of nerve pulses are crucial for the neural coding of odors [**?**].

The first thing to come in mind that temporal patterns correspond to memetic code words having length of almost 127 bits ($2^{127}-1$ patterns are possible) with bits represented by a pulse or absence of it. The presence of pulse would correspond to some minimum intensity of field. The first bit would be always 1 to signify the beginning of the codon which would give 126 bits. Also a formal representation as superpositions of Fourier components with frequencies $f_n = n/T$, $n = 1, ..., 127$ with coefficients can be considered but would not be so natural than pulse representation.

There are however objections against this identification.

1. p-Adic length scale hypothesis would predict duration of 100 ms for AM patterns representing memetic code words if.1 second time scale corresponds to the time scale assignable to electron CD. Quite wide length variation for MEs is however possible and 100 ms MEs predicted by p-adic length scale hypothesis could be interpreted as resonant MEs in this picture, ELF frequency counterparts of on mass shell particles whereas other durations would correspond to off-mass shell "virtual" MEs. This interpretation is consistent with the generalization of the ideas of Jaynes [K86, K87].

2. That memetic code could be represented also in terms of MEs conforms with the computer metaphor which suggests myriads of representations of the memetic code. On the other hand, the highest frequency involved would be of order kHz and outside EEG range. Furthermore, AM patterns should represent abstraction and classification of temporal nerve pulse patterns associated with the memetic code words. The generalization of EEG to a fractal hierarchy of EEGs allows however to circumvent the objection.

The simplest thing one can imagine is that a compression of the $2^{127}-1$ neuronal memetic codewords to genetic code words having length of 7 bits giving 127 code words occurs: in this case the the highest frequency would be in the range $58.3 - 87.5$ Hz which relates very naturally to the EEG frequency range and is above the 40 Hz band and various lower bands related to the place coding. One can argue that just as at DNA level only the 64 mutually consistent Boolean statements amongst the $2^7 - 1 = 127$ Boolean statements are realized physically.

Genetic code could be also realized as nerve pulse patterns. This option looks natural in the case of rate coding with almost random time intervals between nerve pulses. If stochastic resonance forcing the autocorrelation function of the nerve pulse pattern to have peaks at the multiples of the forcing frequency is involved, then the number of distinguishable code words would be also around 64. Also the discrete values of the pulse rate varying from 0 to 64 pulses per.1 seconds could define genetic codons.

Magnetic representation of the genetic codewords

Genetic code for odors is consistent with the assumption that the modulation frequencies are in the range $20 - 80$ Hz. The cyclotron frequencies of all biologically important ions including DNA are above 1 kHz so that amplitude modulations at EEG frequencies are slow.

The modulated cyclotron frequencies would naturally represent carrier waves coding for some geometric data, for instance the distance of the object of perceptive field on the sensory magnetic canvas. This prediction could be tested by looking whether the attention directed to a moving object is accompanied by a shift of some cyclotron frequencies.

EEG waves with well defined frequencies would have interpretation in terms of frequency coding by sequences of "notes" whereas chaotic EEG waves such as beta waves might be assignable to the speech like representation. For "note" representation trivial code word would correspond to a mere alpha wave modulation. alpha wave begins to dominate when eyes are closed which suggests alpha wave modulation represents "no sensory input". In the case of vision alpha wave would assign the color quale black and the mental image "darkness" to the region of the perceptive field. In the

case of hearing the trivial codeword would represent the experience of silence, something different from the absence of auditory experience.

Data compression as frequency cutoff and threshold coding

Some comments about the compression process and about the plausibility of the representation of Boolean statements at the level of conscious experience are in order.

1. The compression process simply drops away the bits corresponding to the frequencies above 80 Hz. This kind of frequency cutoff is precisely what is carried out in quantum field theories when the effective action for low energy theory is constructed. For quantum field theorist this means functional integral over the frequencies and wavelengths above the cutoff frequency and cutoff wavelength. Thus brain would apply the counterpart of the same procedure as quantum field theorist or statistical physicist uses to build simplified models applying in time and length scales above the inverse of the cutoff frequency and cutoff wavelength.

2. The values of the EEG potentials need not be discrete to yield bit representation at the level of the conscious experience if magnetic quantum phase transition is induced only if the intensity of the oscillatory magnetic perturbation defined by ME is above certain threshold value. Threshold coding is actually what is expected since phase transitions should occur as a kind of domino effect. There is also an upper bound for the harmonics of the cyclotron frequency which can be amplified to a macroscopic quantum phase transition. This yields automatically frequency cutoff even in absence of a frequency cutoff for EEG waves.

8.3.2 Synchronization

Cognitive functions like perception, memory and language are based on parallel and highly distributed information processing. What brain does is the analysis of the sensory input into bits. One of the major unresolved questions of brain science is how the information these bits can be integrated to sensory percept and how coherent representational states can be established. Temporal binding has been suggested as a mechanism making this possible. The synchronized neuronal firing has been proposed as an underlying mechanism of temporal binding inside and between various cortical areas. The assemblies of neurons firing synchronously could even define neuronal correlates for objects of perceptive field. Synchrony mechanism would apply also to motor actions and allow selection of perceptually and behaviorally relevant information. Temporal binding has been proposed by Crick and Koch as a necessary and sufficient condition for the generation of conscious percepts. It however seems that 40 Hz synchrony corresponds to generation of information.

In TGD framework the synchronously firing neuronal assemblies are excellent candidates for sub...selves. Synchrony should result from the presence of a TGD counterpart of a computer clock ticking with a frequency of order kHz associated with the memetic code.

Empirical evidence for kHz synchronization

Neuronal synchronization is by now a well established phenomenon (see [**?**] and references therein).

1. Synchronization inside and between sensory, motor and associative areas has been established. Synchronization has been observed also inside subcortical structures such as lateral geniculate nucleus, superior colliculus and brain stem and even in retina [**?**]. Synchronization has also found even between areas belonging to different hemispheres.

2. Synchronization in visual system predicts synchronization inside visual areas and between areas across large cortical distances. These predictions have been verified. For instance, two neurons fire synchronically only if they respond to the same visual object but not otherwise. It has been found that the basic criteria for the gestalt formation (such as continuity and coherent motion), shown to support by perceptual grouping, are also important for the formation of a synchrony between the neurons of the visual cortical. Synchronization has been studied also in non-visual modalities: synchronization in the olfactory systems of various vertebrate and invertebrate species has been found and both auditory and somatosensory

cortex has been demonstrated to show precise synchronization. Synchronization has been observed also in hippocampus and frontal cortex.

3. Synchronization has been observed in motor areas and between areas of sensory and motor system. For instance, the study of cats performing visuomotor tasks has shown that the synchronization between visual and parietal as well as visual and motor areas occurs in those task epochs where the animal processes attentively information to direct the required motor response.

4. Synchronization seems to serve as a neural correlate for conscious percepts [**?**]. For instance, in binocular rivalry, the neuronal activity in V1 does not change when the consciously perceived stimulus changes. However, highly synchronous firing is what distinguishes the perceived stimulus from the non-perceived one.

In TGD framework this would mean that the entanglement with magnetic body serving as the correlate for the directed attention would have synchronization as a neural correlate. The interpretation would be that without synchronization no coherent cognitive or emotional mental image is formed at the magnetic body.

Charge entanglement involving W MEs makes possible superpositions of several sensory percepts and state function reduction would select one of them. The possibility to build quantum superpositions of alternative percepts means metabolic economy since only single percept need to be realized in a given quantum parallel universe. The selection of percepts in binocular rivalry might be a basic example about state function reductions at the level of perception. Information processing resembling quantum computing could be realized using quantum superpositions of nerve pulse patterns. Same picture applies also to motor action. When a large number of similar systems (say sensory receptors) is involved, quantum statistical determinism guarantees reliable perception.

EEG and MEG studies demonstrate that high frequency components of sensory evoked potentials exhibit precise neuronal synchrony in the awake state but disappear in deep anesthesia [**?**]. A possible interpretation is that Josephson radiation at 1 kHz frequency ceases as a consequence of anesthesia. This conforms with the fact that anesthetes affect cell membrane. For instance, a phase transition changing the Planck constant associated with 1 kHz cell membranes by the action of anesthate could lead to the disappearance of 1 kHz frequency.

Also gamma (40 Hz) synchronization is enhanced during arousal and focused attention as well as during a conscious perception of distinct auditory events and of coherent visual stimuli during attentive visual search. Again the interpretation would be in terms of Josephson currents which get more intense or appear as a phase transition increasing the Planck constant by factor 4 for neuronal membranes with 10 Hz Josephson frequency. Note that 40 Hz Josephson frequency corresponds to Josephson wavelength of about 3 meters.

Dark Josephson frequencies and corresponding parts of the magnetic body scale like $r = \hbar/\hbar_0$ whereas the corresponding body parts would scale like $\sqrt{r}$. This gives the map of wavelengths to the sizes of the body parts suggested by the findings about water memory and which I have used to refer to as scaling law. Scaling law will be discussed in the last section.

Temporal binding by synchronization

The article of Engel *et al* [**?**] provides an excellent representation about the development, motivations and the recent empirical status of temporal binding by neuronal synchrony. The article contains also references to the original work and the references to the results represented below can be found from this article and are not separately mentioned.

There are many reasons why for binding by synchronization. Later also empirical evidence suggesting that synchronization accompanices only the formation of percept rather than percept itself is discussed.

1. Synchrony provides the counterpart of computer clock making possible a precise presynaptic summation of the neural inputs in turn implying fast and precise and fast neural processing. Synchrony makes also possible coordinated changes of the synaptic efficacies: this is of obvious importance for the associative learning at synaptic level. Also the robustness of neural processing is implied: army does not need single man.

2. Synchronized neuronal assemblies define natural candidates for the neural correlates of conscious percepts and synchronization might be a basic mechanism of attention.

3. The information processing in brain is known to be highly parallel and distributed: for instance, there are about 30 distinct visual areas in monkey brain. Synchronization between various sensory, motor and associative areas has been proposed as a candidate for the mechanism generating coherent gestalts.

4. Synchronization has been proposed as key element for functions like learning and short term memory. Quite generally, it seems that non-synchronized brain regions are analogous to a computer without a global computer clock and thus seats of neural chaos.

5. Synchronization has been also suggested by Crick and Koch to be a necessary and sufficient condition for conscious experience to occur. From the TGD point of view and on general philosophical grounds this hypothesis seems to be too far-fetched. Rather, synchronization seems to provide the counterpart of computer clock in TGD framework feeding order in neuronal chaos. Synchronized regions define however natural correlates for sub...selves.

What is the dynamics of volition and thought?

The proposed simplified view leaves open some fundamental questions which basically relate to how the geometric correlate of intentional action. There are two basic questions.

1. How the dynamics of thought generation is realized?

The understanding of the feedback from the sensory (real) level to the cognitive (p-adic) level is required. More precisely, how sensory (real physics) input is transformed to cognition.

p-Adic physics as physics of cognition is a fundamental key idea of TGD inspired theory of consciousness. For long time I believed that p-adic-to-real transformations of space-time sheets realized as quantum jumps could serve as correlates for the transformation of intentions to actions allow deeper understanding of also psychological time as a front of p-adic-to-real transition propagating to the direction of the geometric future. It turned out that the mathematical realization of this idea might involve unsurmountable challenges and the natural vision is based on adeles: both reals and various p-adic number fields would be present and cognition would be present already at elementary particle level as also the p-adic mass calculations suggest.

The original belief was that the transformation of real space-time sheets to p-adic l ones in quantum jump would correspond to the generation of thoughts. It is now clear that this hypothesis is both un-necessary and difficult to realize mathematically.

Rather, TGD Universe is adele meaning that both embedding space, space-time, and WCW are adelic structure containing real sector and various p-adic sectors as correlates of cognition. Real space-time sheets representing classical space-time correlates of physical events are automatically accompanied by p-adic space-time sheets defining what might be called cognitive representations. Intention in turn is part of the experience of self identified as a sequence of state function reductions at fixed boundary of CD and dying when the first state function reduction to opposite boundary occurs and gives rise to a volitional act of higher level self having self as a mental image.

2. How the dynamics of volition is realized?

The idea that negative energy MEs representing signals propagating to the geometric past represent volitional acts conforms with the ZEO based view about volitional action as state function reduction at opposite boundary of CD reversing the arrow of geometric time.

Zero energy ontology allows to formulate the notion of negative energy ME rigorously. They are space-time sheets associated with CDs for which time runs in non-standard direction. In ZEO volitional action would be in a formal sense time reversal of the sensory perception with signals initiating the action propagation in time reversed direction from magnetic body to brain and eventually to the level of motor neurons.

This idea has become rather precise after the formulation of quantum measurement theory in terms of ZEO [K61, **?**, K7]. In ZEO self corresponds to a sequence of state function reductions at fixed boundary of CD changing only the situation at the opposite boundary (in standard quantum measurement theory nothing would happen to the state). This sequence gives also rise to the

development of intention. The volitional action begins with the first state function reduction to the opposite boundary of CD and means that the sub-self (mental) images dies and reincarnates at the opposite boundary of CD. This picture leads to a simple answer to most basic questions and seems to be the correct one.

A general view about the role of synchrony

The hypothesis that synchronization is due to the presence of MEs suggests the following general view about how conscious brain functions.

1. The basic states for the various areas of brain could represent more or less chaotic neuronal activity without synchrony. During sleep primordial neuronal chaos might be realized in the scale of the entire cortex.

2. Negative energy MEs would select from the sea of cortical chaos islands of order and generate objects of perceptive field or behavior (by sensory-motor analogy one might perhaps speak of "behavioral field") realized as sub-selves. MEs would obviously feed negentropy to the neuronal primordial chaos and generate macro-temporal quantum coherence and thus sharp sub-selves lasting for a sufficiently long time to contribute significantly to the contents of consciousness and behavior (note the analogy with a social group: very short-lived member does not contribute significantly to the development of the social group).

3. The question whether there exist non-neuronal correlates for consciousness is definitely settled in this framework: they do exist and correspond to both p-adic and real charged and neutral MEs both in the sense of electro-weak and color interactions and the synchronous firing of neurons provides a direct experimental evidence for these correlates visible already at the primary sensory areas.

4. The mesoscopic feature level visible in EEG and reflecting the synchrony MEs could represent a higher abstraction level in which memetic code words are compressed to the genetic code.

This view combined with the general vision about the realization of the various representations represents a reasonably coherent vision about how magnetic body controls brain. There remains of course challenges even at the level of principle.

8.3.3 40 Hz 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 [**?**] challenging the simplest view about the role of 40 Hz synchrony in binding.

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 [**?**]. 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 [**?**]. 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 [K38].

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.

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 [K102, K61]. 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 enchanged 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 oxiditative 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.

8.4 Stochastic Resonance And Brain

This section begins with the review of the notion of the stochastic resonance. Also its applications to neuronal systems are reviewed. With motivations coming from conceptual difficulties of the proposed neuronal models, a reduction of the stochastic resonance to the quantum level, which is assumed to control the functioning of bio-systems, is developed by refining the quantum model

for nerve pulse generation by specifying the interaction with MEs. Another key idea described in detail in [K19] is that bio-systems correspond to flow equilibria for ions in the many-sheeted space-time with atomic space-time sheets having the role of a controlled system and super-conducting space-time sheets taking the role of the controlling system. The possibility that MEs generate by stochastic resonance soliton sequences associated with Josephson currents, is discussed.

8.4.1 Stochastic Resonance

Background noise is usually seen as a mere nuisance in communications but under certain circumstances it can in fact improve, rather than hinder the performance. The notion of stochastic resonance [D6] was originally put forward by Benzi and collaborators [D5] in seminal papers where they study the problem of the periodically recurrent ice ages. The same suggestion was raised independently by C. Nicolis and G. Nicolis [D17]. The planetary glaciation sequence has a period of about 10^5 years which happens to be same as the period of the planetary gravitational perturbations with a typical time scale of 10^5 years inducing an extremely small (of about .1 per cent) periodic variation of the solar constant which as such cannot explain ice ages. The system is modelled by a bistable potential in which the two potential wells represent the ice-covered Earth and the normal climate. Short term climate fluctuations are modelled by white noise and if the intensity of the white noise is correct, the weak periodic variation of Earth's temperature is amplified to a synchronized hopping between cold and warm climates.

The notion of stochastic resonance has been considerably generalized to include a number of different mechanisms. The unifying features are the increased sensitivity to small perturbations and phase locking for an optimal noise level. Stochastic resonance like features have been reported also for autonomous systems. Also the quantum version of the stochastic resonance taking into account quantum tunnelling has been studied. Stochastic resonance has been also generalized to coupled (that is higher-dimensional) systems and to excitable systems allowing only single stable state and meta-stable states. The interested reader can find references to the rich literature about stochastic resonance in [D6].

Stochastic resonance has been verified for a wide variety of system such as Schmitt trigger, bistable ring laser, electron paramagnetic resonance, and super-conducting quantum interference devices (SQUIDs) [D6]. An especially important application is to neuronal systems [D19].

8.4.2 Basic Model For Stochastic Resonance

The archetypal model of stochastic resonance involves a one-dimensional system equivalent with a particle with mass m moving in a double potential well

$$V(x) = -ax^2/2 + bx^4/2$$

under a friction force $\gamma dx/dt$ proportional to velocity, a weak periodic external driving force $A(t) = A_0 sin(\Omega t)$, and a random force which can be modelled as a white noise $\xi(t)$ with vanishing mean and correlation function

$$\langle \xi(t_1)\xi(t_2) = 2D\delta(t_1 - t_2) \ .$$

Here the parameter D characterizes the noise level.

The noise could be also a more general colored Gaussian noise with ultraviolet frequency cutoff. The fluctuation forces cause transitions between the potential wells with a rate given by the Kramers rate [D13]:

$$r_K = \frac{\omega_0\omega_b}{2\pi\gamma} exp\left[-\frac{\Delta V}{D}\right] \ . \tag{8.4.1}$$

Here $\omega_0^2 = V''(\pm x_m)/m$ is square of the frequency of small oscillations at the bottom of well and $\omega_b^2 = -V''(x_b)/m$ is an analogous quantity estimated at origin which correspond to the maximum of the potential. ΔV denotes the height of the potential barrier separating the two minima.

If a periodic spatially constant force is applied to the particle, it induces a periodic variation in the shape of potential. At a given well the minimum of the potential barrier occurs periodically

with frequency Ω and if the particle hops to second well when barrier height is minimum it experiences minimum height barrier in the second well after a half period. If the white noise is such that the rate r_K is twice the frequency Ω:

$$r_K = 2\Omega \ , \tag{8.4.2}$$

the rate for the jumps between potential wells is synchronized with the periodic variation of the external force. One can understand this relationship intuitively on basis of the previous simple observations.

Stochastic resonance is manifested as a phase locking of $x(t)$ to the external force and as maximum of the average amplitude as function of the parameter D characterizing the noise level when the resonance condition is satisfied. In linear response theory, which is appropriate when the condition $A_0 x_m << D$ is satisfied, the approximate expressions for the average amplitude and phase shift read as

$$\begin{aligned} \overline{x} &= \frac{1}{m\gamma\omega\omega_b}\frac{A_0\langle x^2\rangle_0}{D}\frac{2r_K}{\sqrt{4r_K^2+\Omega^2}} \ , \\ \overline{\Phi}(D) &= arctan(\frac{\Omega}{2r_K}) \ . \end{aligned} \tag{8.4.3}$$

$\langle x^2\rangle_0$ denotes the variance for the unperturbed noisy system. The distribution of time intervals between hoppings has characteristic peaks at $T = 2\pi/\Omega$ and its integer multiples.

The phase averaged power spectral density $S(\omega)$ defined as the Fourier transform of the correlation function $\langle x(t+\tau)x(t)\rangle$

$$S(\omega) = \int_{-\infty}^{\infty} exp(-i\omega\tau)\langle x(t+\tau)x(t)\rangle d\tau \ , \tag{8.4.4}$$

exhibits delta peaks at frequencies $(2n+1)\Omega$ superposed to a noise background $S_N(\omega)$ whereas even multiples of Ω correspond to dips. This reflects the reflection symmetry of the double potential well. The heights of the spectral spikes behave as A_0^{2n} and since the periodic perturbation is assumed to be weak, it is possible to restrict the consideration to the first spike ($n = 1$). In the linear response theory one obtains following expressions for the noise density $S_N^0(\omega)$, total spectral density $S(\omega)$, and signal-to-noise ratio:

$$\begin{aligned} S_N^0(\omega) &= 4r_K\frac{\langle x^2\rangle_0}{\sqrt{4r_K^2+\Omega^2}} \ , \\ S(\omega) &= \frac{\pi}{2}\overline{x}(D)^2\left[\delta(\omega-\Omega)+\delta(\omega+\Omega)\right]+S_N(\omega) \ , \\ SMR &\equiv 2\left[lim_{\Delta\omega\to 0}\int_{\Omega-\Delta\omega}^{\Omega+\Delta\omega} d\omega\right]/S_N(\Omega) = \pi(\frac{A_0 x_m}{D})^2 r_K \ . \end{aligned} \tag{8.4.5}$$

8.4.3 Stochastic Resonance And Neuronal Systems

During the last decade stochastic resonance has become a well accepted paradigm in the biological and neurophysiological sciences [D19]. This despite the fact that neuronal systems are excitable systems with only single stable ground state and a short-lived excited state with lifetime of order millisecond which can be short as compared to the typical driving frequency. The simplest models effectively assume that neuron is a bistable system. The most obvious functions of the stochastic resonance in neuronal systems are the amplification of weak periodic signals (such as the noise produced by a predator) and temporal coding (say in auditory nerve).

In TGD framework the natural question is whether the stochastic resonance really occurs at the neuronal level or at a deeper control level. If the latter option is correct, the simplest paradigm of bistable system might be enough to model the system.

Empirical evidence for stochastic resonance in neuronal systems

The encoding of acoustic information on the primary auditory nerve of mammals has been studied for a half century. It has been known that, in contrast to the conventional theory, the information about the frequency of the stimulus is coded also to the inter-spike distribution of the spike sequence. This correlation between neuronal input and output is known as phase locking in neurophysiology and presents one particular form of temporal coding [**?**]. It is needless to emphasize that various forms of temporal coding and its reverse process are absolutely crucial in TGD based model of qualia.

Longtin, Bulsa and Moss [**?**] observed that inter-spike interval histograms of periodically stimulated neurons of a cat exhibit a remarkable resemblance to the return time distributions of a periodically driven noisy bistable system with Gaussian noise for which correlation function decays exponentially:

$$\langle \xi(t)\xi(t')\rangle = \frac{D}{\tau_c} exp\left(-\frac{|t-t'|}{\tau_c}\right) \quad . \tag{8.4.6}$$

Return time is defined as the time for the system to be kicked from one well to another and back again. With only one fitting parameter it was possible to achieve an excellent agreement. Neuron is definitely not a bistable system and this forces to ask whether the assumption about the underlying bistable system might make sense at some deeper, controlling level.

Moss and collaborators studied also the behavior of the mechanoreceptor cell of a crayfish [**?**] by stimulating it with an input consisting of a sum of single tone and noise. The spectral properties of the action potentials were analyzed, yielding a power spectrum typified by a background noise plus sharp peaks at multiples of the frequency of the stimulus. Also signal-to-noise ratio was studied and was found to resemble the shape of the corresponding curve for a bistable system although the resonance peak as function of the noise intensity does not decrease so fast as for stochastic resonance in a bistable system.

Stochastic resonance has been demonstrated to occur also in the hair cell of cricket [**?**]. In this case the function of the stochastic resonance is to help the detection of a weak periodic signal (a coherent motion of air created by say predator) from a huge noisy background.

Models of stochastic resonance based on standard neuroscience

Several phenomenological models reproducing the stochastic resonance for inter-spike interval distributions have been proposed.

1. Neuron firing and Poissonian spike trains

The simplest model is based on the idea that neuron emits uncorrelated sharp spikes at random times [**?**] The spiking rate $r(t)$ is however sinusoidally modulated and the specification of $r(t)$ defines the model. One can express the phase averaged spectral density $S(\omega)$ for the spike train as a sum of frequency independent white noise term $\overline{r}$ and sum of delta peaks at frequencies $\omega = n\Omega$:

$$\begin{aligned} S(\omega) &= \overline{r} + 2\pi \textstyle\sum_{n=1}^{\infty} |r_n|^2 \delta(\omega - n\Omega) \quad , \\ r_n &= \tfrac{1}{T} \textstyle\int_0^T r(t) exp(-in\Omega t) dt \quad . \end{aligned} \tag{8.4.7}$$

The rate theory for noise-induced barrier crossing in the presence of a periodic external force suggest the generalization of the Kramers rate formula for the hopping rate r_D between potential wells to

$$r(t) = \nu \times exp\left[-\tfrac{\Delta V}{D} - \tfrac{A_0 x_m}{D} cos(\Omega t)\right] \quad . \tag{8.4.8}$$

Here ΔV is the barrier height in absence of forcing, D is noise strength, A_0 is the amplitude of the periodic driving force, and the scale factor x_m characterizes the position of the potential well. The

pre-factor ν depends on the details of the process. This formula should make sense for sufficiently low frequencies Ω (adiabatic approximation).

By calculating the Fourier transform of $r(t)$ one obtains for the signal to noise ratio defined as the ratio

$$SNR = \frac{2\pi r_1^2}{\bar{r}} \simeq \frac{\pi x_m^2 A_0^2}{D^2} exp\left(-\frac{\Delta V}{D}\right) \quad . \tag{8.4.9}$$

Signal-to-noise ratio shows a behavior characteristic for stochastic resonance. The comparison with the data from the mechanically modulated mechanoreceptors of a crayfish shows qualitative agreement with this prediction although the decrease of SNR for large noise levels is overestimated by this model. The parameterization of $r(t)$ is based on the assumption that system is effectively bistable: this is of course not true at the neuronal level.

3. Integrate and fire model

Integrate and fire model assumes that the input of the neuron consists of a spike train $i(t)$ (cortical neurons) or a continuous signal (sensory neurons) [D6], [**?**]. The membrane voltage $u(t)$ is obtained by integrating the input $i(t)$ represented as a current through the membrane. By representing cell membrane as a capacitance C and resistance R the equation of motion for the membrane potential reads as

$$\frac{d}{dt}u = -\frac{1}{\tau_{RC}}u + \frac{i(t)}{C} + \frac{\xi(t)}{C} \quad . \tag{8.4.10}$$

Here one has $\tau_{RC} = RC$. Gaussian white noise with a zero mean is assumed. In the case of a perfect integrator ($1/RC = 0$) the Fokker Planck equation for the probability distribution for the potential values as a function of time reads as

$$\frac{\partial P(u,t)}{\partial t} = -\left[i_0 + A_0 cos(\Omega t)\right]\frac{\partial P(u,t)}{\partial u} + D\frac{\partial^2 P(u,t)}{\partial u^2} \quad . \tag{8.4.11}$$

The equation states that probability is conserved for the flow in the phase space defined by u and velocity variable $\partial_t u$. Initial values are $P(u = b, t) = 0$ at threshold stating that particle is absorbed at $u = b$. The rate for crossing is given by $r(t) = dP(u = b, t)/dt$.

The distribution function for the inter-spike intervals is given by the mean-first-passage time distribution ρ which is essentially the probability $P(b \to b)$ that the random walk in the external driving force leads from the point $u = b$ representing the threshold for nerve pulse generation ends up for the first time back to $u = b$. This probability can be calculated using Wiener integral for a particle performing random walk in the external force field defined by the periodic perturbation at the half-line $u \geq b$. The first passage distribution shows a multi-peaked structure with higher peaks suppressed exponentially. For a sufficiently large stimulus the peaks are located at $t_n = nT$, $T = 2\pi/\Omega$. The heights of the peaks decay exponentially. The peaks heights run through a maximum as a function of the noise strength D.

This model is unrealistic for several reasons. For instance, the phase of the sinusoidal stimulus is reset after every spike so that the coherence of the stimulus is eliminated.

4. Neuron firing and threshold crossing

One can improve the integrate and fire model by allowing the resistance to be finite and modify it by assuming that the phase, rather than being reset, does not change at all in the emission of a nerve pulse [D6], [**?**]. One can solve $u(t)$ from the previous equation in absence of the noise explicitly by assuming that the amplitude of the driving force is so small that the threshold is not crossed in the absence of the noise. This gives at large values of time

$$u_\infty(t) = i_0 R + \frac{A_0 R}{1 + \Omega^2 \tau_{RC}^2} sin(\Omega t - \phi_{RC}) \quad . \tag{8.4.12}$$

Here one has $tan(\phi_{RC}) = \Omega/t_{RC}$. The presence of the ohmic current induces the reduction of the threshold to $b - i_0 R$. Gaussian colored noise is assumed to cause the crossing and the generation of the nerve pulse, which is for simplicity idealized with a delta peak.

The problem of calculating the rate for the threshold crossing can be formulated mathematically as a random walk on half line $u \geq b$ in presence of an external force using a semiclassical approximation for the Wiener integral over all paths. This means a functional integration over small perturbations of an unperturbed solution to give the probability $P(t)$ that an arbitrary path of the particle leads to the threshold $u = b$ during time interval t. The rate $r(t)$ for the threshold crossing is given as $r(t) = dP(t)/dt$. In [**?**] $r(t)$ the threshold crossing rate is estimated for a colored Gaussian noise and one finds stochastic resonance also now. The formulas are not reproduced here: the interested reader can find them in [D6].

This model effectively assumes that the membrane potential is driven by an external driving force and that the phase of the membrane potential is not appreciably affected by the emission of the spikes. This is consistent with the idea that there is some deeper control mechanism giving rise to the stochastic resonance and that neural level is only the controlled level.

8.4.4 How Neuronal Stochastic Resonance Could Be Realized At Quantum Level?

There is no doubt that neuronal systems exhibit stochastic resonance. The excellent fit of the inter-spike interval distribution by a return time distribution for a bistable system in the case of the auditory nerve of a cat suggests that genuine bistable system might be somehow involved. It is however not at all clear whether it is possible to understand the emergence of the stochastic resonance without leaving the framework of the standard Hodgkin-Huxley theory.

1. Neuronal systems are excitable media rather than bistable systems and it is not at all obvious whether excitable media allow stochastic resonance.

2. The time scale for the return of a neuron to the resting state is of order milliseconds and can be much shorter than the period of the driving external force. Thus the intuitive picture behind stochastic resonance need not make sense at neuronal level. Perhaps one should turn the attention to a more fundamental level, and interpret nerve pulse activity as a result of quantum control with the bistable system to be identified acting as a control system.

The previous model for sensory receptor applied to hearing suggests that perhaps a plausible model of stochastic resonance could be obtained by including besides neurons also a system able to represent sensory input as evoked potentials giving rise to cognitive and/or emotional representations in the manner discussed. This system could be sensory receptor such has hair cell or an aggregate of glial cells (the possible role of astrocytes for brain functioning has been discussed earlier in [K53]).

As found, periodic signal and white noise affecting bistable system are the key factors in the stochastic resonance. Astrocytes would induce the spiking of nearby neurons whereas spike activity and/or microtubular input would generate perturbations of the astrocyte membrane potential which might perhaps allow idealization as white noise. In the case of sensory receptor the source of white noise could be neuronal and/or microtubular back projection.

The basic prediction is that the frequency of the stochastic resonance has an exponential sensitivity to $1/D$, where D characterizes the intensity of the white noise assumed to be generated by the neural activity. The noise level should correlate with the average firing rate if neurons are responsible for the white noise. Also microtubular white noise could be induced by the neuronal firing. The intensity of the white noise should be under automatic or conscious control so that important frequencies could be spotted out from the sensory input by "tuning to the correct wavelength" by varying the level of (possibly neural) noise. The reduction of the resting potential generates higher level of spontaneous firing so that the level of alertness would correlate directly with the value of the spotted frequency for neural noise option.

In the case of sensory organ the oscillatory signal would be contained in the sensory input represented as an evoked potential. In the case of astrocytes the oscillatory signal would be contained to the sensory signal mediated by microtubuli inducing oscillating evoked membrane

potentials V. For hearing V could represent electric counterpart of a sound wave with a well-defined frequency. V would modulate Josephson frequency since it would appear as an additive component in membrane potential besides membrane voltage.

Stochastic resonance should transform a frequency associated with the sensory input V to a peak frequency in the autocorrelation function for spikes so that spike interval distribution would reflect the frequency of the sensory input and its harmonics. For sound frequencies sufficiently below kHz this is easy to understand since the membrane potential oscillates in the same rhythm as the sound wave. Above kHz frequency rate coding does not make sense.

If neuron is Josephson junction it could serve as a system allowing bistability and stochastic resonance. Josephson junctions are indeed known to allow stochastic resonance [D4] but this situation applies to small oscillations of the phase difference Φ over the junction with regions $\Phi > 0$ and $\Phi < 0$ identified as the analogs of the two potential wells. The two state should correspond to firing and non-firing states of the neuron and the model for nerve pulse and EEG identifies the resting state as a state in which Josephson junction is mathematically analogous to a rotating pendulum but with so low a rotation velocity that small reduction of the rotation velocity leads to an oscillation mode. The reduction of membrane potential below the critical value for nerve pulse generation would reduce the rotation velocity and would reduce the rotation to oscillation and induce nerve pulse. The return to the original state would be automatic. The transition between the two states (no firing induced or firing induced) would be induced by the neuronal noise with Kramer rate equal to two times the frequency of the periodic stimulation.

Astrocyte system could control the level of the neural noise acting like a listener of the radio turning the knob to find the station. The position of knob would be replaced with the level of the neural noise. A feedback loop between the two systems would make possible to find the optimal noise level. Glutamine-glutamate cycle for astrocyte-neuron interaction could make this system possible.

8.5 Temporal Codings

An impressive evidence exists for the temporal coding [**?**] despite the fact that the dominant view has for long time been that rate coding is all that is involved. The vision about MEs as quantum holograms suggests that nerve pulse patterns are coded to the pulse patterns of the light-like current along ME. The hierarchy of Planck constants and the model of EEG in terms of Josephson radiation suggests a quite precise realization for the brain as orchestra metaphor with frequency modulation used as the basic tool to represent information.

8.5.1 Basic Structure Of EEG In TGD Framework

It is known that EEG decomposes to sum of two parts: the part consisting of relatively few fundamental frequencies and their harmonics and the quasi-continuous part, "noise". Both the amplitudes of harmonics and fundamental frequencies fluctuate.

Josephson current of particular ion is proportional to $sin(Q_{eff}\int(V_0 + V_1 + V_{noise})dt)$, V represents fundamental frequency, V_1 to spike contribution, and V_{noise} to the neural noise. The current and thus also Josephson radiation can be decomposed by basic trigonometric formula to the sum

$$sin[Q_{eff}\int(V_0+V_1)dt]\times cos[Q_{eff}\int V_{noise}dt]+cos[Q_{eff}\int(V_0+V_1)dt]\times sin[Q_{eff}\int V_{noise})dt] \quad .$$

The integral over the noise is small so that one has $cos[Q_{eff}\int V_{noise}dt]\simeq 1$ and $sin[Q_{eff}\int V_{noise}dt]\simeq Q_{eff}\int V_{noise}dt$ giving a representation which might be consistent with the observations.

What is new that the noise level is amplitude modulated. If the frequency of the stimulus is high as compared to the Josephson frequency, the neuron automatically performs variation of the noise level in order to find ideal noise level for stochastic resonance during the period. This is like automaticized periodic turning of the knob back and forth to identify the correct wave length.

The fluctuation of the frequencies would be due to the fluctuation of the membrane potentials and the fluctuation of the amplitudes due to the intensity of Josephson currents.

Due to the fact that the neuronal membrane is near to the threshold for firing the treatment of the noise as something small is justified only if the amplitude of the noise remains low enough. Indeed, stochastic resonance becomes possible and leads to neuronal firing in the rhythm defined by external perturbation.

8.5.2 TGD Based Overall View About Temporal Codings

The following is a summary about TGD inspired attempt to build an overall view about temporal codings.

Brain as orchestra metaphor

1. The prevailing neuro-scientific view is that the resonance frequencies of EEG can be assigned to resonances in neural circuits. In TGD inspired picture nerve circuits are not necessary and there are reasons to believe that this kind of resonances are too wide to explain kHz resonances frequency or even sharp EEG resonances. Rather, EEG frequencies are reduced to Josephson frequencies assignable to the effective cell membrane potential and are proportional to the membrane potential. The energies of corresponding dark photons are in visible and UV range and their decay gives rise to either EEG photons or bio-photons. The spectrum of frequencies is dictated by the spectrum of the preferred Planck constants and the scale of spectrum depends on ion and value of membrane potential.

   Singing whale provides a good metaphor for how EEG codes for the information carried by neuronal activity since the small perturbations of the membrane potential and even nerve pulse induce frequency modulation of the fundamental frequency. Depending on the character of perturbation the situation corresponds to singing or speech (when recorded speech is represented slowly it becomes clear that also now frequency modulation is involved). If preferred Planck constants come as powers of to dictated by Mersenne hypothesis then also brain as orchestra metaphor becomes surprisingly precise.

2. The interference of perturbations of the membrane potential from presynaptic cells means that membrane potentials are summed up so that rate coding is only partial description and it is indeed known that emotional aspects of speech cannot be produced using only this information. At the level of brain an attractive hypothesis is that the signals from neurons are transferred to glial cells as small perturbations and communicated to the magnetic body therefrom.

   "Note" and "phoneme" representations (song and speech) defining emotional and cognitive representations would be realized as temporal patterns of evoked potentials at the level of sensory receptors and glial cells. Genetic or even memetic code could be realized in case of speech like representations. The hierarchy of Planck constants allows very complex hierarchy of frequency modulations induced by the interaction of nearby neurons and glial cells and by spike activity. The aggregates of glial cells could be in the role of highest level in the representational hierarchy. Orchestras have soloists and one can wonder whether soloists are now analogs of Grandma neurons or groups of neurons or glial cells producing especially intricate frequency modulation patterns. Features include also spatial modulation patterns.

4. That neural transmitters and modulators control resonance frequencies in neural circuits is also a natural hypothesis in neuroscience context. In TGD framework neural transmitters and modulators can affect average firing rates and also the intensity of neural activity by controlling the resting value of the membrane potential and sensitivity for the firing. Glial cells might also participate on this control in accordance with idea that they take the role of conductor.

Codings

Several kinds of codings reducing basically to frequency modulation can be considered and also here orchestra metaphor helps to imagine various options. First kind of could would rely on nerve pulse patterns and the perturbations induced by these.

1. The cortical representation of audible frequencies above 1 kHz requires representations using evoked potentials of glial cells and the transfer of sensory input as Josephson radiation along sensory pathway and/or as acoustic/electric oscillations of microtubuli to the glial cells is a necessary prerequisite of this representation. The cortical feedback via outer hair cells expands the audible frequencies above 1 kHz in the case of mammals and makes possible the representations of EEG frequencies as frequency modulations of the Josephson frequencies for the aggregates of glial cells. This representation would emerge in frontal lobes.

2. Also the coding of (say sound) frequencies based on spike interval statistics is supported by experimental findings and is possible for frequencies below 1 kHz. This representation might be induced from the above discussed representation at the level of glial aggregates and sensory receptors via stochastic resonance. Periodic signal and white noise affecting bistable system are basic elements of stochastic resonance. Astrocytes induce the spiking of nearby neurons whereas neuronal noise affects astrocytes. Suppose that astrocytes receive also sensory signals mediated by microtubuli inducing oscillating evoked membrane potentials V of astrocytes.

   Stochastic resonance would transform V to a peak frequency in the autocorrelation function for spikes. Glutamine-glutamate cycle for astrocyte-neuron interaction could define the neuron-astrocyte interaction with astrocytes taking the role of radio listener tuning the neurons to a specified wavelength by using the level of noise as a knob.

3. Rate coding defines the roughest coding and would relate to the perturbations of resting potentials of glial cells induced by spike patterns. For the rate conding the temporal pattern of spikes does not matter.

4. The proposal that nerve pulse patterns could realize genetic or even memetic code is one of the earliest TGD inspired conjectures. The time scales of CDs assignable to electron and d quark provide additional support for this idea. In the proposed framework the realization would be in terms of frequency modulation patterns induced by spikes and in principle could realize genetic code by allowing maximum flexibility. 10 Hz alpha rhythm would specify uniquely the time intervals containing the genetic codons. The discrete value of the firing rate expressed as the number of spikes per period of 10 Hz alpha wave would realize genetic codon as an integer $n \leq 63$. One can however argue that memetic code looks somewhat too rigid a representation to be used by a musician.

   The hint about what might be involved comes from the fact that music is also recorded and nowadays the recordings are digital. Millisecond and 100 ms time scales characterizing nerve pulse activity and features correspond to the standard value of $\hbar_0$. Maybe genetic and memetic code representations result via the interaction between large $\hbar$ space-time sheets with space-time sheets with the same time scale of CD but different Planck constant and p-adic prime. $\hbar_0$ space-time sheets would represent the lowest level of this interaction hierarchy. Mersenne hypothesis indeed relies on this interaction transforming dark weak bosons to their lighter counterparts with a lower value of Planck constant. This interaction would produce something analogous to a binary representation of music piece as a CD able to regenerate to the original experience to some degree and might be of special relevance for long term memory and cognition. The model for the sensory receptor provides a concrete representation for how this transformation could take place [K38].

Objections against temporal coding can be circumvented in TGD framework

There are several objections against temporal coding which all involve in an essential manner the relationship between subjective and geometric time. If t=constant snapshot represents the reality, as believed in standard quantum physics, the inclusion of frequencies and temporal patterns does not make sense except phenomenologically. In TGD approach the problem disappears since quantum states are quantum histories. The quantum jump sequence represented by a nerve pulse pattern corresponds to subjective time development as hopping between geometric time developments characterized by EEG patterns. Each nerve pulse affects slightly the EEG pattern.

This raises the question whether EEG record represents the EEG spectrum associated with the space-time surface generated in the last quantum jump or whether it is some kind of an average

over the EEG spectra over quantum jumps. If the recording of EEG is completely automatic process, it is updated in every quantum jump and represents EEG at the space-time surface generated in the last quantum jump and, rather paradoxically, is therefore changing all the subjective time. The experiments of Radin and Bierman support this view [**?**]. Also the experiments related to the timing in active aspects of consciousness suggest that the EEG of the past changes in the interval which is a considerable fraction of second [**?**] and long time scale compared to the millisecond time scale of nerve pulse patterns.

8.5.3 As If Time Really Mattered

Not only physics, but also neuroscience is plagued by the tensions caused by the erratic identification of the subjective time with the geometric time. There are two views about how nerve pulses patterns code for the sensory data. The first, and still dominating, view is that firing frequency codes for the intensity of the sensory experience. Competing view is that temporal patterns of nerve pulses code for the sensory information (fore a review see [**?**]).

In TGD framework first approach can be seen as emphasizing the dynamics with respect to subjective time whereas temporal patterns with respect to geometric time are neglected. Both memetic code and spectroscopy of consciousness rely crucially on temporal patterns with respect to geometric time. Hence these approaches are in conflict with the standard view about time. The approach based on temporal coding in the framework of the classical field theory forgets the dynamics with respect to subjective time and concentrates on the dynamics with respect to the geometric time. One however ends up with philosophical paradoxes circulating around time-frequency uncertainty relation: it is difficult to understand how communication is possible at all in deterministic classical world.

Quantum jumps between quantum histories view fuses both of these approaches to a more general unified description. The excellent review article "As if time really mattered: Temporal strategies for neural coding of sensory information" by Peter Cariani about temporal coding will be referred to several times in the following discussion. This article also reviews the difficult problems of frequency coding approach [**?**].

8.5.4 Rate Coding Contra Temporal Coding

Rate coding is the dominating view about the representation of the sensory data in neuroscience and most neural net models rely on this approach. The approach is based on three assumptions.

1. Rate coding is the whole story: the average rate of firing defined by an interval with duration of ten to few hundred milliseconds codes the intensity of the sensory input.

2. Everything is ultimately coded into spatial patterns and spatial rate differences somehow code all relevant sensory information. The standard coding relies on rate-place scheme: average firing rate increases along one-dimensional axis. In TGD this hypothesis is generalized in the sense that brain is assumed to build miniature virtual world model of the space-time and that magnetic transition frequencies code for the values of the spatial and temporal coordinates.

3. A further element is connectionism: in some manner the architecture of the neural pathways gives rise to qualia associated with it.

Geometric time is completely absent from rate-coding based model of brain. This is what mere quantum statistical determinism neglecting the notion of quantum history and the physics of the classical em fields associated with them would leads to. In particular, EEG is mere epiphenomenon in this approach. What makes the situation so problematic is that neural net models describing information as purely spatial patterns can always reproduce the observed behavioral patterns by brute force by introducing a sufficiently complex neural network. From modelling perspective this might be nice but need not have anything to do with how Nature does it. The situation has been however changing during the last decade. The observations about the correlations of EEG patterns with conscious experience, the successes of neurofeedback [**?**], the realization of the potential importance of 40 Hz coherent oscillations in binding, and a rigorous experimental

proof for the temporal coding of odors [**?**], are forcing the view about brain as a system in which classical em fields are important.

Temporal coding provides alternative and much more general approach but, as already noticed, has also its problems which relate to the fundamental confusions about the relationship between geometric and subjective time. There is empirical evidence for the occurrence of temporal coding in virtually every sensory system [**?**] . One can imagine many temporal coding mechanisms but the most important ones rely on spike interval statistics and latency-place representations.

Temporal coding provides solutions to the three basic difficulties of the rate coding paradigm: contrast degradation problem, pattern recognition problem and multiple object problem or "superposition catastrophe". Contrast degradation implied by the saturation of the firing rates at high stimulus intensities. Good example of pattern recognition problem is related to the perception of pitch. Same pitch can be generated in very many ways: by monochromatic sound; by a sequence of clicks; or even by a superposition of multiples of fundamental frequency not involving the fundamental frequency itself as in the case of periodic pitch phenomenon. It is very difficult to understand how the stimulus coded to a spatial representation based on mere firing rates could even contain the information needed to decode the pitch. For temporal coding these problems are almost trivial [**?**]. Superposition catastrophe is identity problem for different objects of perceptive field. For instance, how it is possible to identify the sound of a familiar person in large crowd of people or distinguish transparent object from a nontransparent one, and how it is possible to group sensory inputs to form objects of perceptive field? In temporal coding approach common temporal structures allow to define objects of perceptive field: for instance, points of perceptive field moving in the same direction or behaving synchronously belong to the same object.

8.5.5 Spike-Statistics Coding In TGD Framework

The idea about temporal coding by spike-interval distributions or by some other distribution of time scales associated with the nerve pulse patterns (say intervals between spike bursts) resonates strongly with the spectroscopy of consciousness idea.

Spike-interval statistics and EEG

Spike interval statistics is rather successful. For instance, the information provided by single nerve fiber is enough to reproduce recognizable speech. The correlation of EEG with contents of consciousness experience could be understood by the effect of spike sequences on EEG waves. In the standard framework EEG waves are assumed to be excited by neuronal loops at subcortical level.

Several experiments described in [**?**] however suggest that spike-interval coding could occur also at subcortical level which supports the view that the necessary information is present already at the level of sensory receptors as indeed assumed in TGD inspired model. In TGD framework nerve pulse patterns would stimulate frequency modulations of EEG waves with frequencies identified as Josephson frequencies and since EEG waves transfer information about sensory data to the magnetic body, the success of the spike interval statistics can be understood.

Multiplexing and broadcasting

Multiplexing means the possibility of transmitting several messages simultaneously as superpositions of different harmonics. In TGD context this means frequency modulations coming as superpositions of this kind and are coded to the EEG waves directly. In the case of small oscillatory perturbations one can apply the product formula to the Josephson current to obtain an approximate linear superposition at the level of Josephson current.

Josephson radiation should affect also neurons and glial cells - in particular regeneration of sensory quale could be possible [K38] - and the attractive possibility is that resonance like situation occurs when the period of the oscillatory perturbation coincides with the average Josephson frequency of the receiving cell and leads to a selection of only this particular contribution from the signal.

This mechanism makes also possible broadcasting is possible: the same message or superposition of messages can be send as Josephson radiation propagating along axonal flux tubes or

larger flux quanta at which axonal flux tubes are topologically condensed. This allows mass communications and depending on Josephson frequency of receiving cell, only part of the message is received.

This kind of communication mechanism -if it involves radiation at larger space-time sheets- would provide a mass media type communication mechanism depending only weakly on the connectivity of the neural circuitry. Brain as a neuron society metaphor indeed supports the view that besides neural chatting also mass communications are important. In particular, mass communications might be involved with the synchronous firing of the neuron groups. Combined with the possibility of simultaneous superposition of various data in EEG pattern, broadcasting mechanism replaces the rather poorly defined problem of computing the representation of the external world from spatial firing rate patterns by direct experiencing. The computational problem is transformed to understanding how experience of, say, motion is represented by magnetic quantum phase transitions. Of course, the very assumption that computation gives rise to conscious experience is completely ad-hoc hypothesis.

The role of transmitters and modulators in generating correct EEG frequencies?

The recovery periods for neurons vary from milliseconds to seconds. Recovery time can be affected by neurotransmitters as well as neuro-modulators. Many axons [**?**] show triphasic recovery period consisting of refractory period, super-excitable phase and depression phase. Clearly, neuron favors inter-spike intervals for which the next spike arrives in neuron during super-excitable phase. Many-levelled hierarchy of neuronal pathways could thus serve as a sequence of sieves selecting preferred frequencies. Emotions are known to affect strongly the information processing in brain but not to alter the information content and peptides as molecules of emotion expresses the importance of these molecules as correlates of the emotional state.

Josephson radiation is absent during recovery period. During the refractory period the Josephson frequency would be higher, during refractory period low, and depression phase presumably higher again. This would allow to code information about the state of the neuron in terms of the pitch of the neuronal song.

Neurotransmitters and neuro-modulators control among other things the value of the resting potential. Besides small scalings of the resting potential also phase transitions changing the value of Planck constant and leading to a new octave could take place. Neither of these changes afffects the information but could code for the emotional state. For instance, alpha and 40 Hz bands could relate by this kind of scaling and the TGD inspired model for EEG during sleep assumes that a phase transition increasing the value of Planck constant by a factor of two occurs twice [K38]. It is known that "hippocampal theta frequency" varies in wide limits [**?**] and that its value correlates with the state of arousal [**?**]. This could be due to both $\hbar$ changing phase transitions and smooth change of the resting potential.

Resonant generation of complex motor activities?

There is also the fascinating possibility that a characteristic EEG pattern induces complex self-organization patterns giving rise to the basic building blocks of motor actions or even patterns of them. If this is really the case, then characteristic EEG patterns could serve as names for self-organization processes. This idea is of course not new and is expressed eloquently already by Ernst Mach [**?**] .

Multiplexing and mass communications based on the selective receival by resonance mechanism indeed makes possible for single temporal pattern to carry very complex superposition of EEG frequencies with each frequency coding for a particular spatiotemporal position in the virtual world of brain and exciting neuron in that particular position and leading to to a generation of a complex spatiotemporal pattern amplified to motor action by puppet in string mechanism.

8.5.6 Applications Of Spike Interval Coding

Spike interval statistics codes information in the temporal pattern. This information can be information about the temporal or spatial pattern of the sensory stimulus (audition, vibratory sense)

or about the non-geometric quale (this might be the case in the case of color vision, tastes and odors).

Empirical data support following type of spike-interval coding. The dominating time interval ΔT in the spike sequence codes for the heard frequency below kHz: $f = 1/\Delta T$ in the case of audition. The intensity of experience is measured by the ratio of the power in dominant interval to the power in non-dominant intervals [**?**]. This relationship holds true generally. This code gives frequency coding by averaging.

The nice feature of temporal coding mechanism is the possibility of multiplex coding: same nerve pulse pattern can contain simultaneously several messages represented by spike patterns which are mutually orthogonal with respect to the inner product defined by Fourier transform. For instance, information about color, shape and temporal pattern of illumination might be coded as a superposition of nerve pulse patterns. In the following some well established examples about this mechanism [**?**] are discussed.

Hearing

Hearing involves both spatial coding of frequencies in the sense that special points of cochlea are especially sensitive to frequencies around the center frequency. This is not however the whole story. Rather, it would seem that this frequency serves only as a carrier frequency for amplitude modulated messages generated by the pattern of nerve pulses. The spike sequences for nerve fibers specialized to a given center frequency contain spike intervals which code for various qualities of sound like pitch, timbre and phonemic identity. Rather remarkably, the spike distribution of single nerve fiber contains enough information about speech to make possible speech recognition [**?**] .

One problem related to the pitch quale is that nerve pulse rates are able to code only for the frequencies considerably below kHz and one must understand the coding of frequencies above kHz. Coding of the frequency by the modulation frequency of Josephson radiation provides a solution to the problem. One could even assume that there is a resonance in the sense that the modulation frequency of the frequency equals to the frequency itself [K78] so that the Josephson current decomposes into harmonics of the fundamental frequency. This would mean that EEG patterns would be analogous to harmonics sounds produced by music instruments. Of course, also non-harmonic sounds can be considered.

In the phenomenon of periodic pitch superposition of the harmonics of fundamental frequency, which is not itself present in the superposition, generates experience of pitch at the fundamental frequency. Periodic pitch has also visual counterpart which can be understood as coding of the visual textures along lines to temporal patterns by scanning. Periodic pitch can be understood if one assumes coding of the temporal patterns to spike patterns. The point is that any superposition of Fourier components not containing constant term is periodic function with a period determined by the fundamental frequency and must have at least one zero in the period since the integral of this function vanishes and must therefore change its sign at least once in the period. Thus sensory stimulus vanishes at least once during the period which means that threshold crossing occurs periodically and generates spike train. This periodicity in turn implies that also EEG contains the fundamental frequency.

In TGD framework also the feedback from cortex via outer hair cells to the inner hair cells is needed to generate fundamental frequency as an artificial auditory input.

Two visual/auditory/tactile stimuli are experienced as separate if the time interval between them is longer than 25 ms/.01 ms/5 ms. For hearing the time interval is by a factor 1/100 shorter than the millisecond time scale of nerve pulse which suggests that nerve pulse patterns cannot code for the high frequency part of the auditory stimulus. The representations of the auditory stimulus as evoked potentials at hair cells and glial cells inducing frequency modulations of Josephson frequencies would resolve the problem.

One cannot avoid the temptation to understand these time scales in the framework provided by Mersenne hypothesis involving the Planck constants $r = 2^{k_d}$ with preferred values of k_d and the time scale hierarchy assignable to CDs. 25 ms corresponds to the CD time scale (secondary p-adic time scale) $T(125)$, 6.25 ms corresponds to $T(123)$ and to the time scale of CD assignable to u quark and .012 ms to $T(112)$. The values of k_d for these scales come from $T(k_d) = 2^{k_2} 1/f(2\ eV)$ are $k_d \in \{45, 43, 35\}$. They are all odd whereas the allowed values of k_d are even for the most stringent form of the Mersenne hypothesis. The corresponding p-adic length scales are 5.12 m,

2.56 m, and 32 cm, which corresponds to the size scale of head.

Tactile senses

Humans can perceive vibrations applied to skin in the range $5 - 1000$ Hz. The so called rapidly adapting receptors code for 5-100 Hz frequency range whereas Pacinian corpuscle receptors code for 30-1000 Hz. There is evidence that this ability relies on or at least involves spike statistics coding. The temporal patterns of the vibratory stimulus are evident in the temporal discharge patterns of all units at all stations in the ascending somatosensory pathway. In TGD framework the spike patterns would reflect the deeper coding in terms of glial evoked potential patterns.

It is known that the ordering of the inter-spike intervals is disrupted by jitter along neural pathway to cortex. Note that the loss of information about temporal ordering is not important for our sensory experience which is temporal average over quantum jumps over time interval of at least .1 seconds as suggested by the fact that temporal resolution of sensory experience is about .1 seconds. If the time separation between visual, auditory, or tactile stimuli is above 20 ms, their temporal ordering can be perceived correctly. It could be however that the reaction to the sensory input is associated with some lower level self and that at our level averaging over longer time scale occurs.

Spike interval codes has also been reported for pain, touch, temperature and nociception (for more details and references see [**?**]). These modalities are highly emotional which suggests that the temporal interference patterns of Josephson radiation code for the emotional content.

Chemical senses

Odor discrimination relies on spatiotemporal coding of odors [**?**]. The facts about olfaction and gustation does not fit well with the hypothesis that connection structure of the neural pathway somehow codes for the quale. This hypothesis requires that the connection structure should be more or less static. Both taste buds and olfactory neurons have limited lifespans. Cells of taste bud move from center to boundary during the life cycles and are innervated by different axons during their life cycle. In TGD framework these problems disappear.

Taste discrimination experiments [**?**] have demonstrated that electrical stimulation using the spike patterns stimulated by odorant reproduce the emotional expressions following the perception of the real odor. When temporal pattern is changed by keeping the firing rate same, emotional response disappears. This is consistent with the assumption that "emotional" representations experienced by us are realized at the level of glial cells and that neuronal spike patterns are enough to excite the frequencies involve with these representations. Second type experiments demonstrate that electrical stimulation of an individual taste bud generates taste experience. This would suggest that the frequency giving rise to taste quale is excited automatically by the sensory stimulus and that each cell of taste bud generates it own primary taste.

Vision

In the case of vision there is psychophysical evidence for the temporal coding of color, texture and form. Color sensations can be produced using achromatic temporal patterns. Any color can be induced by the appropriate pattern of luminal changes. Benham's top is a famous device used to achieve this [J3]. Also electric stimulation of retina can directly induce color sensations. In TGD framework the color sensation in the case of Benham's top should result from the back projection from glial cells to the sensory receptors induced by the achromatic temporal pattern communicated to glial cells and would involve genuine generation of photons which could be also dark photons. The stimulation would take place by dark photons with energies in visible region but frequencies much lower than those of ordinary visible photons: 80 Hz frequency associated with retina is a good candidate for this frequency (this frequency corresponds to a dark p-adic length scale of 1.8 m).

Also ordinary visible photons could be transformed to dark photons before the arrival to the photoreceptors. It is known that photoreceptors are obscured by three or four coats of neurons. This has been traditionally represented as an example of not so intelligent design. One should be however rather cautious before making this kind of statements. It has turned out that these cells act as optical fibres [**?**]. One can however still wonder why this complex manouvre is needed.

The possible answer is that in this manner communications from both brain and external world to retina are optimized. Optic fibres could also induce the leakage of these photons to dark space-time sheets.

In TGD framework color qualia could be seen as coding spatial gradients of the illumination at a particular wavelength (in consistency with the color constancy phenomenon) to subjective experience. The saccadic motion of the eye would code a spatial change in the illumination to a subjecto-temporal gradient represented by the increments of appropriate color quantum numbers in quantum jump. This phenomenon is related to the color sensations stimulated by suitable frequency patterns of achromatic illumination [**?**]. What would happen that some colors present in the achromatic illumination would be amplified more than others. How precisely the coding of spatial illumination gradients to color qualia occurs is a challenge for TGD approach but it seems obvious that classical color gauge fields accompanying always classical electromagnetic fields must be an essential element of this coding.

Scanning and saccadic motion suggests itself as a fundamental mechanism generating at neuronal level temporal maps of the surface texture. Each line of the perceptive field scanned by the saccadic motion could give rise to spikes at those moments when the line is crossed by the saccadic line. Neighboring neurons would in turn code the direction of the line to the direction of a line in space-time-plane: line would be like space-time orbit of particle. There is empirical evidence for multiplex coding of information about visual form and color (for more detail and references see [**?**]). Also information about changing illumination seems to be coded into spike-statistics.

8.5.7 Latency-Place Representations

Latency-place representations use relative time-of-arrival differences to code information about the intensity of the sensory stimulus. Since latency typically decreases with intensity, the contrast degradation problem is circumvented. As absolute latencies decrease, so do the variances of latency distributions. Latency differences can be amplified more centrally by lateral inhibition since the impulses can excite inhibitory units which can inhibit regions surrounding the region with the shortest latency. This mechanism might be involved with the generation of space-time sheets representing objects of perceptive field. Variants of the latency-place representation can be involved with vision (motion perception), electroception, auditory, somatosensory, olfactory and gustatory systems.

Co-incidence detection is basic mechanism related with the formation of latency-place representations for position or direction. There is evidence that pyramidal neurons in cortex apply coincidence detection [**?**]. In the case of hearing, which is the most studied case, coincidence detection occurs in brain stem. In many vertebrates, inter-aural time differences are used to deduce the azimuthal direction of the sound source at frequencies above kHz whereas at lower frequencies phase differences between waves entering into separate ears are used for this purpose. The general mechanism uses pathways from corresponding positions of right and left ear to an array of coincidence detectors in brain stem such that the length difference for the pathways varies linearly with the array coordinate. Only that part of array fires for coincidence for which the delay caused by the length difference between right and left pathways compensates the time lapse between signals to separate ears. The time difference for the arrival times of the signal to two ears is thus coded to spatial coordinate and this coordinate represents information about azimuthal angle characterizing the direction of the sound source.

It is interesting to notice that music metaphor reflects itself also at the level of brain anatomy [**?**]. Brain resembles piano in that distances along axes coding different temporal or spatial frequencies depend logarithmically on frequency ratios: this guarantees the invariance of the sensation with respect to the scaling of frequencies. It might have also something to do with the hallucinatory states in which objects of the external world are perceived as gigantic or miniature sized: perhaps hallucinatory state leads to anomalous frequency-scales for some objects of the perceptive field.

In TGD the comparison of parallel supra-currents representing sensory inputs to be compared makes possible coincidence detection at quantum level. When two identical supra currents flowing in parallel super conductors and forming Josephson junctions enter at same time they are in the same phase, resonant Josephson current is generated and wakes up sub-self giving rise to mental image about coincidence and also generates nerve pulse activity giving rise to further

experiences.

8.5.8 Do Brain Areas Correspond To Particular EEG Resonance Frequencies?

The scaling law of homeopathy inspires the guess that the information processing hierarchy, which starts from the primary sensory organs and contains besides sub-cortical nuclei also primary, secondary, etc... sensory areas, corresponds to a hierarchy of increasing EEG resonance wavelengths. This is consistent with the idea that primary, secondary and higher sensory areas of the cortex correspond to the periods of the periodic table in increasing order such that gamma band corresponds to the primary areas. Similar hierarchy should be realized at the motor areas.

This hierarchy should be realized dynamically by resonantly amplifying the EEG MEs with fundamental frequencies near the resonance frequency associated with a particular brain area. Neural circuits generating nerve pulse patterns, whose autocorrelation function contains the resonance frequency, could form a part of the mechanism. Alfven resonance could be even more important. If the magnetic flux loops associated with the magnetic body of a given brain area have a particular length L, one expects that the ELF MEs passign around the magnetic loop acting as a wave guide are amplified, when the fundamental frequency of the ELF ME satisfies certain resonance condition. This passage might involve several reflections but one might hope that only single curvilinear ME parallel to the magnetic flux loop acting as an Alfven wave guide is needed. In this case the length L of the magnetic flux tube would correspond to the resonance frequency $f = c/L$.

The generalization of this argument to the case of super-symplectic resonance frequencies would suggest the following scenario.

1. Primary sensory areas correspond to tertiary excitations of $k = 5_2^3$ algebra with the fundamental frequency of 40 Hz to primary excitations of $k = 251$ with fundamental frequency of 28 Hz. It is also possible that $k = 83_3$ excitations with frequency 56 Hz are associated with primary sensory areas and subcortical areas.

2. Secondary sensory areas correspond to secondary excitations of $k = 127$ with fundamental frequency of 10 Hz, average frequency in alpha and fundamental frequency associated with memory.

3. Tertiary association areas turn correspond to $k = 2^8 = 256$ with fundamental frequency 5 Hz belonging to theta band.

4. Unimodal association areas correspond to $k = 257$ with fundamental frequency of 3.5 Hz, the upper end of delta band.

5. Multimodal association areas would correspond to secondary excitations of $k = 131$ with fundamental frequency .63 Hz.

Of course, one could shift the positions of p-adic length scales along cortex but the assignment of 40 Hz to primary sensory cortex suggests that the identification could be correct. The mirror mechanism of long term memories suggests that an analogous hierarchy is realized at much lower frequency scales in terms of MEs and magnetic flux loops.

8.6 Scaling Law

Scaling law provides bird's eye view about transitions which can represent conscious-to-us qualia at given level of the p-adic self hierarchy. I ended up with the scaling law much before the realization that sensory representations could reside outside the brain and have same sizes as EEG MEs. The hypothesis that scaling law relates the sizes of the magnetic flux tube structures outside the body serving as a magnetic canvas to the sizes of the sensory representations inside brain implies that the view about hierarchy of magnetic body becomes rather quantitative. The scaling law has several forms and the latest of them is based on the hierarchy of Planck constants.

8.6.1 Various Forms Of Scaling Law

Scaling law relates two levels of self hierarchy corresponding to mental images associated with magnetic bodies of possibly astrophysical size and with physical bodies, the latter with size not much larger than brain size. Scaling law assumes that self sizes L at given p-adic level k are between the p-adic length scales $L_e(k)$ and $L_e(k(next))$. Scaling law is of form

$$L = \frac{v}{f} = \frac{v}{c}\lambda \ , \tag{8.6.1}$$

and relates ELF self size characterized by ELF frequency f (wave length λ) to the self size L and to the effective phase velocity v of the EEG wave.

With the discovery how non-episodal/declarative long term memories could be realized, came the realization that the scaling law could also relate the sizes of magnetic loops involved with positive frequency MEs propagating with sub-luminal effective phase velocity v along magnetic flux tubes and negative frequency MEs propagating with light velocity along much larger flux loops. Quite generally, it would seem that it is magnetic structures associated with positive and negative energy MEs, whose sizes are related by the scaling law.

The input from the work of Cyril Smith [I16] led to a variant of the scaling law stating the existence of imprinted frequency pairs (f_h, f_l) such that the presence of f_h implicates the presence of f_l and vice versa and satisfying

$$\frac{f_h}{f_l} \simeq 2 \times 10^{11} \ . \tag{8.6.2}$$

Also other values for the ratio can be considered. Scaling law in this form is discussed in the chapters [K49] and [K53]. One can interpret this scaling law in terms of $L = v/f_l$ law if one identifies the ratio of frequencies as velocity $v = f_l/f_h$.

The hierarchy of Planck constants leads to a further development in the understanding of the scaling law. For dark matter hierarchy the scaling law relates the time scale defined by Josephson frequency f expressible as

$$\begin{aligned} f &= r f_0 \ , \ L = \frac{\sqrt{r}}{f_0} = \sqrt{r}\lambda \ , \\ r &\equiv \frac{\hbar}{\hbar_0} \ . \end{aligned} \tag{8.6.3}$$

The second form of the scaling law corresponds to

$$\frac{f_h}{f_l} = \sqrt{r} \tag{8.6.4}$$

with $r = 4 \times 10^{22} \simeq 5 \times 2^{75} = .944 \times 2 \times 10^{11}$. The error is 6 per cent. Note that the value of Planck constant would correspond to a ruler and compass integer but would be more general than allowed by Mersenne hypothesis. The imprinting process associated with the water memory would correspond to phase transitions changing the value of Planck constant. One of them transforms large $\hbar$ dark photons to ordinary photons with same energy having interpretation as bio-photons and also the reversal of this transformation is possible. Second one transforms large $\hbar$ photons to bunches of photons of generalized EEG photons with the same frequency and probably does not have reversal.

If one assumes also the first form of the scaling law, one can conclude that there is a velocity parameter given by the expression

$$\frac{v}{c} = \sqrt{\frac{1}{r}} \ . \tag{8.6.5}$$

This velocity could have several interpretations. It could correspond to the velocity of nerve pulse conduction, of propagating EEG wave, or of Ca^{++} wave. The velocities of the latter waves vary in extremely wide range. If EEG corresponds to Josephson radiation then the effective velocity of EEG wave could correspond to the disturbance of the propagating soliton sequence induced by the resting potential, which is most naturally at rest in the rest system of the soliton sequence. Hence the propagation of EEG wave could be interpreted as the conduction velocity of the solitons sequence or equivalently that of the nerve pulse.

If this interpretation is correct, the value of the Planck constant assignable to a given neural pathway are glial cell cluster could be measured. Nerve pulse velocities vary in the range 1-100 m/s and increase with the radius of axon. One would have $r \in \{2^{43}, 3 \times 2^{55}\}$ and $r \simeq 10^{14}$ would correspond to 5 Hz EEG frequency. The corresponding frequency range would be 80 Hz-.032 Hz. The latter scale corresponds to.51 minute period for the generalized EEG. These bounds look realistic.

If v corresponds to a velocity of EEG wave (it is not clear whether they indeed propagate), one can deduce the corresponding value of Planck constant and frequency from v as well as the size scale of the body part involved. This gives the consistency condition

$$\frac{f}{f_0} = r = (\frac{c}{v})^2 \tag{8.6.6}$$

allowing to test the hypothesis. Here f_0 is the photon frequency (around 2 eV for -50 mV resting potential: see the tables of [K38]) defined by the energy of the dark Josephson photon and is proportional to the membrane potential and thus varies with certain limits. The right-hand side is constant so that the Josephson frequency must be proportional to EEG and different ions must correspond to different brances of generalized EEG. If EEG waves are assumed to propagate with the same velocity as EEG waves the hypothesis reduces to the above case, which seems to be consistent with what is known about the range of EEG frequencies.

The phase velocity of the soliton sequence can be either $v < c$ or $v = c^2/V > c$, $V < c$ and this suggests that these velocities correspond to two kinds of EEG waves. $v = c^2/V > c$ gives standing solitons at the limit $V \to 0$: in practice even $v = c$ gives effectively standing waves. The phase velocities larger than light velocity would formally correspond to the values of Planck constant smaller than the standard value. Physically these waves would correspond to the firing of the entire axon simultaneously and are excluded.

If one accepts the identification of velocity in terms of Planck constant completely generally and allows only sub-luminal velocities, then only integer valued Planck constants are possible because otherwise the velocities could exceed light velocity. Hence only singular coverings of CD and CP_2 would be allowed. Once the value r of Planck constant is known the coverings of CD and CP_2 correspond to different decompositions of r to a product of integers for this option. If singular factors spaces are allowed, an infinite number of decompositions are possible.

8.6.2 Scaling Law For The Qualia About Brain Structure Of Given Size Scale

The classical fields associated with MEs are expected to code information about the contents of conscious experience at various levels of self hierarchy. EEG represents one level in this hierarchy. This coding is crucial for the realization of declarative memory as classical communications from the geometric past. p-Adic length scale hypothesis to estimate how wide the range of frequencies responsible for coding information about conscious experience at given level of self hierarchy is. The model makes a prediction for the number of EEG harmonics representing information about conscious experience at a given level of self hierarchy, and suggests a general law telling what transition frequencies correlate with experiences conscious-to-us.

Relationship between self size and EEG frequency

Scaling law in its basic form reads as

$$\begin{aligned} v &= \lambda f \ , \\ L &= \lambda \ . \end{aligned} \tag{8.6.7}$$

Here v denotes the effective phase velocity associated with the EEG wave, λ corresponding wavelength, and f EEG frequency. L denotes the size of the sub-self and is assumed to be multiple of the effective wavelength associated with the EEG wave. The sub-self in question can give rise to a sensory mental image at the level of primary sensory organs or to a symbolic or cognitive representation at the level of brain.

In TGD Universe effective EEG phase velocities correspond basically to the effective phase velocity for MEs drifting along the relevant brain structure or a closed magnetic loop. The subluminal phase velocity results because positive energy ME tends to hop towards geometric future in quantum jump with some average rate while the space-time sheet representing environment is stationary. This velocity can be super-luminal for negative energy MEs if they dissipate since dissipation in this case would mean gradual shifting of ME backwards in the geometric time. Whether the dissipation really occurs significantly is not at all clear. If the frequency of the negative energy ME corresponds to an energy above thermal energies, the probability that negative energy can be absorbed is very low. This makes negative energy MEs ideal for generating time-like quantum entanglement, which is the prerequisite for the sharing of mental images. This process is the key element of long term memory, and even of the ordinary sensory experience and motor activity.

TGD based model for nerve pulse and EEG relates effective EEG phase velocities to the effective phase velocities of MEs moving along axon and generating the nerve pulse and also cell membrane oscillations [K79]. The dropping of ions to the magnetic flux tubes of the Earth's magnetic field during the process generates positive energy EEG MEs propagating along magnetic flux tubes of the personal magnetic body with sub-luminal phase velocity and representing in their modulation pattern information about the contents of sensory experience presumably crucial for declarative long term memories.

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. In this case the process would occur coherently for all particles. 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.

1. Ordinary states of consciousness and scaling law

One can argue that for the states of consciousness deriving only from ordinary sensory data by information processing in CNS, L cannot be larger than brain or body size for normal states of consciousness. The reason is that ELF self gains the sensory information from nerve circuits when it scans the relevant brain region and it does not make sense to scan regions much larger than brain size. This obviously implies $v < c$.

A stronger hypothesis making sense for ordinary states of consciousness encouraged by the empirical data [**?**] is that apparent phase velocity is actually equal to the conduction propagation velocity of the nerve pulses in the neural pathway involved:

$$v = v_{cond} \ . \tag{8.6.8}$$

2. Transpersonal states of consciousness and scaling law

One could argue that transpersonal levels of consciousness (during sleep perhaps) provide sensory information from several brains simultaneously. Also states of transpersonal consciousness and even cosmic consciousness are difficult unless one allows self sizes much larger than brain size. That this kind of experiences might be possible is suggested by out-of-body experiences in which person sees her own body in eyes of outsider.

1. The first guess was that transpersonal states of consciousness correspond by $L = v/f$ law super-luminal effective phase velocities $v = c^2/V > c$ associated with the Lorentz boosts of time-like soliton sequences. The soliton sequences can be assigned with the possible existing Josephson junction structures connecting parallel super-conducting magnetic flux tubes. The potential differences associated with the junctions are extremely weak and correspond to the EEG frequencies via the formula $\omega = Q_{eff}eV/\hbar$.

2. The second guess is that they correspond to negative energy MEs for which EEG frequencies predict length of the order of the Earth's circumference. Negative energy MEs are indeed natural correlates for the generation of the bound state entanglement and the generation of macrotemporal quantum coherence accompanied by experiences of "one-ness". Negative energy MEs make also possible telepathic sharing of mental images. Episodal (sensory) long term memories would involve negative energy MEs with ultra low frequency scale. The generation of negative energy MEs could also provide metabolic energy by buy now-let others pay mechanism and might explain the claims about the ability of yogis and meditators to survive with minimum nutrition.

It might be that negative energy MEs associated with semitrance mechanism (semitrance mechanism is described in chapters [K86] and [K87] and possibly also with the initiation of motor actions. Positive energy MEs would in turn be involved with long term declarative memories involving classical communication with a sub-luminal phase velocity along closed magnetic loops of size $L = v/f$. These communications could be more or less automatic and the active memory recall could only mean a decision to receive the signal. Hippocampus and amygdala are good candidates for the parts of brain responsible for generating the positive energy MEs responsible for inducing the non-episodal memories.

Memory circuits could be also indirectly responsible for the generation of long term episodal memories. It is indeed known that removal of these structures leads to a loss of, say, hallucinations induced by say LSD [**?**]. In [K80] the mechanism of synesthesia is discussed with the cautious conclusion that the activity in the hippocampal region indirectly induces the generation of long term episodal memories. The over-activity in the memory circuits would induce a "starvation" in certain cortical regions. In order to get metabolic energy these starving regions would apply buy now-let others pay mechanism and generate negative energy MEs inducing a time-like entanglement with the geometric past and a sharing of mental images resulting in episodal memories.

Maximal number of harmonics at given level of p-adic hierarchy

The general vision is that we can have experiences mediating information about several levels of the p-adic length scale hierarchy associated with body. Both primary and secondary and even higher p-adic length scales are allowed in this hierarchy. The sharing of mental images made possible by negative energy MEs and classical communications made possible by positive energy MEs are the main mechanisms involved. Classical communications involve some code translating information to the shape of the classical fields and/or vacuum currents associated with positive energy ME propagating with sub-luminal phase velocity.

To build a model one can make more detailed technical assumptions.

1. For a given p-adic length scale $L_e(k)$ the self sizes between $L_e(k)$ and $L_e(k_{next})$ contribute to the experiences about that level. $v = Lf$ law in turn allows to estimate for a given fundamental transition frequency f how many harmonics contribute to the classical field of ME in question at level k. The number of harmonics determines the maximum information content of the experience generated by the classical signal carried by ME at that level.

2. For a given transition frequency and nerve pulse velocity v_{cond}, which could be for definiteness assumed to be equal to EEG phase velocity, there is some minimal p-adic prime $k(min)$ nearest to the length scale v_{cond}/f:

$$L_e(k_{min}) \leq \frac{v_{cond}}{f} \quad . \tag{8.6.9}$$

The minimal p-adic length scale does not in general allow maximal sensory acuity since v/f is not in general infinitely near to $L_e(k_{min})$.

The next k: s can however give maximal number of transition frequencies corresponding to $[k_{next} - k]/2$ octaves if the spectrum of self sizes is maximal. The frequency band for a given k is filled by starting from the frequency corresponding to the lowest possible "bodily self" size $L_e(k)$, which is the largest possible frequency for that k, and proceeding to smaller frequencies corresponding to larger values of self size. This means that the hierarchy of p-adic length scales coming as octaves of the basic scale very precisely corresponds to the hierarchy of conscious experiences about various length scales. Every p-adic length scale is like music instrument producing $[k_{next} - k]/2$ octaves of musical notes.

Scaling law leads to rather strong predictions when combined with the formula identifying self size as the apparent wave length associated with EEG waves.

For instance in the case of $k = 199$ characterizing the size of brain, there are 6 octaves of frequencies between $L_e(199)$ and next primary p-adic length scale $L_e(211)$. Rather interestingly, the range $1.5 - 90$ Hz of EEG frequencies spans also 6 octaves. ELF self can have also experiences about what it is to be brain hemisphere ($k = 197$): this is possible for suitably tuned drift velocity range of ELF self, in this case the maximal frequency range would be 2 octaves. Amygdala would presumably correspond to $k = 193$ and in this case three octaves of EEG frequencies are possible. One must also consider the possibility that secondary and higher p-adic length scales are involved. In this case $L_3(67) = 32$ cm corresponds the p-adic length scale next to $L_e(199) = 16$ cm.

Communication between different levels of the self hierarchy and fractal scalings

Communication between different levels of p-adic hierarchy means mapping of various functions representing sensory information from a given level p to another level p_1. The obvious manner to realize this mapping is simply to scale by the ratio $p_1/p = 2^{(k_1-k)/2}$. Music piece is transposed to $(k_1 - k)/2$ octaves higher. For instance, actual EEG pattern corresponding to virtual motor activity would be simply its fractally scaled version containing virtual nerve pulse pattern as a repeated command (*"Do this- do this-..."*). It is known that motor neurons indeed serve as low pass filters [B14] noticing only low frequencies and this might correspond to this kind of fractality. Unconscious fine structure of motion could result from unconscious-to-us processing by this kind of fractal scaling. This kind of temporal scaling fits nicely with the paradigm of 4-dimensional brain.

Super Virasoro frequency scales $f(n_1, k_1)$ and $f(n_2, k_2)$ discussed in [K45] differ from each other by power of 2 when both n_1 and n_2 are even or odd. This means that for a given prime super-symplectic transition frequency spectrum is fractal and contains the frequency spectra associated with shorter p-adic length scales as sub-spectra and thus can generate resonantly Super Canonical transitions in shorter p-adic length scales. Similar fractality might be realized for magnetic frequencies. The scaling law $B \propto 1/L^2(k)$ for magnetic field strengths suggested by p-adic fractality would imply that magnetic transition frequency scale scales as $f(k) \propto 1/L^2(k)$.

Is there a correlation between brain size and apparent EEG phase velocity?

A natural assumption is that self sizes at level k are in the range $[L_e(k), L_e(k_{next})]$. $L_e(k_{next})$ can be also secondary or even higher p-adic length scale such that brain size is in the range $[L_e(k), L_e(k_{next})]$. This would give

$$\frac{v}{f} \in [L_e(k), L_e(k_{next})] \ . \tag{8.6.10}$$

An interesting possibility is that there is correlation between brain size and nerve pulse conduction velocity in the neural pathways contributing to consciousness:

$$\frac{v_1}{v_2} = \frac{L_e(k_1)}{L_e(k_2)} \ , \tag{8.6.11}$$

k	191	193	97_2	197	199	67_3	101_2	103_2
L_p/m	.01	.02	2.8	.08	.16	.32	.45	1.8

Table 8.1: p-Adic length scales $L_e(k,n)$ possibly relevant to consciousness and life at length scales relevant to human brain and body. k characterizes p-adic prime via $p \simeq 2^k$ and $n = 1, 2, 3$ tells whether primary, secondary, or higher p-adic length scale is in question. $n > 3$ n-ary scales are assumed to be un-important.

where $L_e(k_i)$ are the p-adic length scales associated with the brains of the organisms 1 and 2 and v_i are velocities in corresponding neural pathways. If this assumption holds true then the maximal information content of the field pattern of ME depends only weakly on the size of the brain since the frequency ranges are more or less the same. That velocity of conduction should increase with the size of organism sounds rather natural since axons get thicker.

It is possible to make definite estimates about conscious qualia for given species using information about nerve pulse velocities involved and about brain size. There is indeed some evidence for the correlation between brain size and inverse of the peak frequency of EEG [**?**]. For instance, it is known that in the case of dog intracranial phase velocities of alpha waves are in the range $.3 - 1.2$ m/s [**?**]. These data suggests that the sizes of alpha wave selves for dog are in the range $3 - 12$ cm so that dog's alpha consciousness would correspond to $L_e(197) = 8$ cm, which is the length scale associated with single brain hemisphere for humans. The result supports the view that the sizes of self correlate with brain size. Large animals like whales could have in ordinary wake-up state sensory input from p-adic length scales above $L_e(199)$ [$L_3(67) = 32$ cm, $L_2(101) = 45$ cm, $L_2(103) = 180$ cm].

If the phase velocity of the alpha waves is same along the entire magnetic flux loops associated with the magnetic body, the values $.3 - 1.2$ m/s *resp.* 14 m/s for the phase velocities of dog *resp.* human would mean that the time span for the long term non-episodal memories would be at least by a factor 1.2/14 shorter for dogs than for humans. This would roughly conform with the dog/human life time ratio.

Consider some examples illustrating what this hypothesis predicts assuming that the velocity range $(v_l, v_u) = (3, 7)$ m/s applies to EEG waves associated with the entire brain and that the doubled velocity range $6 - 14$ m/s applies to single brain hemisphere. **Table 8.1** helps to get overall view about the important p-adic lengths scales.

1. For $k = 199$ corresponding to entire brain the maximal self size L_m, when identified as the next p-adic scale, is $L_3(67) = 32$ cm if tertiary p-adic length scales are allowed. Otherwise L_m is $L_2(101) \simeq .45$ meters. By $v = L/f$ law the ratio $L_m/L_e(199)$ should be smaller than the ratio $v_u/v_d = 7/3 \simeq 2.3$. $L_2(101)/L_e(199) = 2\sqrt{2} \simeq 2.8$ is larger than the ratio $7/3 \simeq 2.3$ whereas $L_3(67)/L_e(199) = 2$ satisfies the constraint so that $k = 67$, which corresponds to rather closely to the length scale of head, is favored.

2. The EEG frequency ranges correlating with qualia conscious-to-us are predicted to be $9.4 - 21.9$ Hz for $k = 67$ and $6.7 - 15.6$ Hz for $k = 101$. The frequency range associated with $L_e(199)$ is $19.0 - 43.8$ Hz.

3. For $k = 197$ corresponding to brain hemisphere one has $L_e(k_{next}) = L_e(199)$ and frequency range corresponding to the velocity range $7 - 14$ m/s is $43.8 - 102$ Hz and for $L_e(197)$ the range is $87.6 - 204$ Hz.

Lower bounds for "bodily" self sizes from the range of nerve pulse conduction velocities

The range for nerve pulse conduction velocities associated with EEG waves does not correspond to the entire range of nerve pulse velocities in somatosensory system ranging from .5 m/s to 120 m/s [B14]. Thus our brain anatomy could allow much wider spectrum of sizes for mental images than allowed by the rather narrow range $3 - 14$ m/s of propagation velocities for alpha waves.

$v/(m/s)$	$.5-2$	$5-30$	$35-75$	$80-120$
$L_e(1,e)/\mu m$	.8-3.2	8-48	58-125	133-200
$L_e(1,p)/mm$	$.27-1.0$	$2.7-5.9$	$19-41$	$44-66$
$L_e(1,Li_+)/cm$	$.1-.5$	$1.2-7.1$	$8.3-17.9$	$19.0-28.6$
$L_e(1,Ca^{++})/dm$	$.3-1.2$	$2.9-17.1$	$20-43$	$46-69$
$L_e(1,Co_+)/m$	$.1-5$	$1.2-7.0$	$8-17$	$18-28$

Table 8.2: Table gives the length scales below which electron, proton and ionic consciousness is possible assuming that the nerve pulse velocities vary in the ranges associated with somatosensory system.

Nerve pulse conduction velocity as a function of the axon thickness obeys the approximate law [B14]

$$v = kv_0 \times \frac{d}{d_0} \quad , \quad v_0 = 1 \ \ m/s \quad , \quad d_0 = 1 \ \ \mu m \quad .$$

The value of k is about 6 for thickly myelinated axons and between 1.5 and 5 for thinly myelinated axons. The variation ranges of conduction velocities in somatosensory (!) system are in ranges $80-120$ m/s, $35-75$ m/s, $5-30$ m/s and $.5-2$ m/s for unmyelinated axons. Conduction velocity varies in rather wide range $(.5-120)$ m/s: "quale key" can vary in a range of almost 8 octaves. The lowering the conduction velocity of nerve pulses by reducing myelinization or thickness could make it possible for us to have qualia about length scales of brain nuclei.

It is interesting to look for the lower bound $L_e(min)$ of self sizes assuming that 90 Hz is upper bound for transition frequencies representing experiences possibly conscious to us. The values of L_{min} are.89 m for $80-120$ m/s range;.39 cm for $35-75$ m/s range; 5 cm for the range $5-30$ m/s and.5 mm for the range $.5-2$ m/s associated with the unmyelinated axons.

Table 8.2 gives the length scales below which electron, proton and ionic cyclotron consciousness is possible assuming that the nerve pulse velocities vary in the range described above. These ranges of nerve pulse conduction velocities are associated with somatosensory system and actual "phase velocities" of EEG waves seem to vary in much narrower ranges.

From **Table 8.2** one finds that electronic cyclotron consciousness is possible in p-adic length scales $L_e(173) = 20$ μm and $L_e(179) = 160$ μm but not above this length scale. Also the length scale $L_e(169)$ might be possible. Protonic cyclotron consciousness is possible at all length scale above $k = 169$ up to $k = 193$.

8.6.3 Scaling Law And Evolution

Scaling law, when combined with general ideas about consciousness, allows to build speculative models for the evolution of consciousness at both biological and cultural level. What would be new and nontrivial would be the strong correlation between cultural and electromagnetic evolution (strictly speaking, also the evolution field bodies is involved). Cultural evolution could be perhaps seen as evolution of memes with memetic code playing the role of genetic code. There are good reasons to believe that the intronic portion of DNA codes for memes represented dynamically as field patterns associated with MEs [K47]. The portion of the introns in genome is indeed large for humans (99 per cent).

Scaling law contra biological, cultural, and spiritual evolution

One can distinguish between two kinds of developments of individual: the neural development of child in the p-adic length scales relevant to body and the evolution of magnetic body and of communications between magnetic body and biological body. Besides the personal magnetic bodies also the magnetic body of Earth, magnetosphere, is expected to carry sensory, cognitive and symbolic representations resulting through entanglement with various organisms. Negative energy MEs in EEG range are natural in this respect. These representations would give rise to

multi-brained magnetospheric selves [K57]. The development at ELF frequency range corresponds by *ontogeny recapitulates phylogeny principle* to the evolution of civilization.

There are good reasons to believe that brain anatomy has remained more or less the same in time scales much longer than the evolution of civilization from bicamerality to modern man. This would mean that the evolution of our consciousness and civilization is basically electromagnetic rather than genetic evolution and corresponds to the evolution of EEG and ZEG during ontogeny. The evolution of magnetospheric consciousness might be a crucial factor in this development. These evolutions are not completely independent since $L = v/f$ ($v < c$) relationship correlates these developments to each other.

1. Scaling law and the relationship between cultural and biological evolution

A fascinating challenge would be to understand the detailed relationship between cultural evolution and the evolution of field body. In particular, there are many interesting questions related to the relationship between self-hierarchy and Freud's ideas. Is super ego above EEG length scales or above the body length scale? Could one regard the counterpart of Id as a species consciousness, some kind of biological superego, in length scales larger than body size but considerably below ELF length scales representing cultural aspects of consciousness? Can one speak of cultural superego? Is the time scale of the phenomenon direct measure for the p-adic length scale of the corresponding self?

It is important to notice that $v = Lf$ relationship defines mapping $k \to f(k)$ between the biological and electromagnetic length scale hierarchies such that ELF self at particular p-adic level has sensory experiences about experiences of particular self at bodily level? Very roughly this mapping would correspond to the scaling

$$L_e(k) \to [\frac{c}{v} L_e(k)] \equiv L_e(f(k)) \ ,$$

where $[L]$ is shorthand for the nearest p-adic length scale below length scale L. More explicit manner to define this mapping would be as

$$k \to [k + log_2(c/v)] \ ,$$

where $[k]$ now denotes the nearest power of prime below k. If this kind of mapping is involved then the evolutions at these two widely different length scales might correspond to each other rather closely.

Evolution at the level central nervous system

The natural implication of the proposed picture is that the biological (as also electromagnetic) evolution of the central nervous system (CNS) proceeds from shorter to longer p-adic scales. Jump in the evolution correspond to emergence of new p-adic length scale when the size of self becomes equal to next p-adic length scale.

This vision about evolution of central nervous system can be tested immediately. Magnetic spectroscopy of consciousness predicts that there are seven levels between $k = 169$ level of neuron and brain and they correspond to the primary p-adic length scales associated with $k = 173, 179, 181, 191, 193, 197, 199$. Central nervous system indeed has 7-levelled hierarchy corresponding to spinal chord, medulla, pons, midbrain, diencephalon, brain hemisphere, brain and higher levels of this hierarchy have indeed emerged one-by-one during evolution. The eight levels of the hierarchy (perhaps it is worth to notice the amusing connection with the eight-fold way of Buddhism and the idea of Lily about eight levels of consciousness) would correspond to the next level of bio-consciousness $k = 211$ which might be already present at delta and theta frequencies.

Geometric consciousness at the level of spinal chord geometric consciousness should at least correspond to multiples of electron cyclotron frequencies. Electronic consciousness is not possible at higher levels. This picture explains why the activities of autonomous nervous system is more or less unconscious to us. Hypothalamus and thalamus and presumably also many other brain nuclei would correspond to the level $k = 193$ in the hierarchy. Their sizes are indeed above 2 cm and below 8 centimeters. Thus autonomic nervous system should correspond to lower level of the p-adic hierarchy of selves so that the contribution to our consciousness would involve several

averageings. Note that protonic cyclotron consciousness is still possible at at this level but not at higher levels for typical conduction velocities of nerve pulses.

Scaling law and ontogeny

During the early development neural pathways myelinize gradually [**?**] and this means gradual increase of the conduction velocities $v = Lf$. This suggest that various versions of quale about given p-adic length scale $L_e(k)$ labelled by the harmonics of the fundamental frequency emerge gradually one by one as nerve pulse propagation velocities in neural pathway increase. First pops up $n = 1$ version of quale, then $n = 3$ version, etc.. One could visualize this as drift of various versions of quale from shorter to longer p-adic length scales.

This predicts that the sensory acuity of infant increases in stepwise manner at critical values of the nerve pulse propagation velocity making possible new harmonic of EEG pattern representing particular quale. The critical values of the nerve pulse propagation velocity for secondary experiences about events at level k are given by

$$v(n) \quad = \quad nf \times L_e(k) \ . \tag{8.6.12}$$

This applies also to motor expression which in TGD framework is very much like virtual sensory experiencing amplified to macroscopic motor activity by puppet-in-string mechanism. For instance, coordination and control of motor activities improves and emotional expression in speech becomes more refined.

This option is not the only one that one can imagine. Also EEG develops during the development of individual. The fact that the peak frequency of EEG moves gradually from delta band to alpha during the first ten years allows to consider the possibility that the sizes L of mental images, stay more or less constant during maturation. This requires that both that nerve pulse velocity and the harmonic of the fundamental frequency giving the dominating contribution to the quale gradually increase. An interesting possibility is that the sizes of selves correlate with body size or with the size of relevant body part during development of individual.

$$L = \frac{v}{f} = k \times L_e(\textit{body part}) \ .$$

This would mean that all ions correspond to the same self size for given value of nerve pulse conduction velocity.

Transition from bicamerality to modern consciousness

TGD based vision about the evolution of civilization relies on *ontogeny recapitulates phylogeny principle* stating that the development of child's electromagnetic body is fractally scaled version of the development from bicamerality to modern consciousness. In particular, the hypothesis has been that this development meant the emergence of higher level emotion and cognition and of the semitrance mechanism in which collective self gave commands and advices to the bicameral.

The proposed model for the evolution of qualia concretizes this general vision considerably. The picture about what might have happened in the transition might perhaps look like follows.

1. Semitrance mechanism

Semitrance mechanism made possible for the collective higher level ELF self to communicate commands and advices to the bicamerals. This higher level ELF self presumably had also higher level sensory experiences about entire social group in some p-adic length scale larger than body size. $L_e(211) = 10$ meters and $L_e(223) = 640$ meters are the most obvious length scales involved. The emergence of new ELF frequencies to EEG meant also that the sensory and emotional acuity of bicameral man improved. It is not absolutely clear whether semitrance is communication of higher level selves to us or sensory experiencing of transpersonal levels of consciousness or both. The predicted lifetimes of transpersonal selves are however measured in years which suggests that they are closely involved with long term memories.

2. Development of speech

The emergence of modern man involved the development of speech faculty. This evolution must have been proceeding in two directions. We have self-narrative in rather long time scales and someone must tell it to us: this implies that ELF MEs corresponding to $k = 127_2, 2^8, 257, 131_2, 263, 89_3, 269, 271, 137_2, 277, 139_2, ...$ should have emerged gradually. This could have also meant development of amplitude modulation hierarchy and increasingly complicated linguistic structures. Note that the time scale starting from .1 seconds ($k = 127_2$) and ending up to 6.1 seconds ($k = 139_2$) contains especially many primary, secondary and tertiary p-adic time scales. This also meant development of increasingly refined linguistic structures in short time scales: words decomposed to syllables and syllables to phonemes presumably identifiable as memetic codewords at $k = 127_2$ level and this made possible development of written language.

In conflict with the standard beliefs about our position in the hierarchy of consciousness, this picture suggests that to some extend both speech and internal speech are speech of higher level self. It is indeed well-known that it is almost impossible to speak fluently if one tries to control what one is saying: one must simply let it go. Also body unconscious-to-us language can be interpreted as talk of higher level self using limbic brain as instrument of expression: this would explain why we express emotional reaction before becoming conscious about the emotion.

3. Emergence of long term memory

What Jaynes believes could be translated to the statement that the transition from bicamerality to modernity involved the emergence of the long term memory and its evolution from a direct sensory memory to declarative memory [**?**]. Sensory memory means direct re-experiencing by the sharing of mental images made possible by time-like entanglement. Declarative memory would be based on a symbolic representation of the data, and would be communicated classically (communication would be ultra-slow!) from the geometric past as a response to the shared mental image representing the desire to remember.

A possible model for long term declarative memories is based on the generalization of the frequency representation of the memetic code. What is presumably coded, are perhaps not details of particular experience but sequence for names of "program modules" realizing particular kind of experience. Thus very high level coding would be in question. In this model long term memories could perhaps be represented as a modulation of the carrier frequency of "hippocampal theta frequency" varying in the range $4-12$ Hz [A5] by multiples of some lower ELF frequency representing higher level of self hierarchy.

The large range of variation for hippocampal frequencies suggest that they could correspond to magnetic transition frequencies of various ions subject to homeostatic regulation. It is indeed known that the state of arousal correlates with the hippocampal frequency. The modulating level would correspond naturally to the ELF self associated with multimodal association regions which project via entorhinal cortex to hippocampus. If the tertiary time scale associated with $k = 251$ (28 Hz) corresponds to primary sensory areas, this region must correspond to $k = 131$ and frequency of .63 Hz and cycle of 1.6 seconds which sounds sensible. If this is the case, long term memories should have natural time unit of 1.6 seconds.

The motion of the peak frequency of child's EEG from delta band to alpha band during the first ten years looks paradoxal against the idea that lower frequencies correspond to higher levels of consciousness. One interpretation for the presence of low frequencies is that the child is in a semitrance state and that the presence of the low frequencies reflects control from the higher levels of self hierarchy. A second interpretation allowing to get rid of the paradox is that the carrier frequency evolves gradually from delta to alpha band while fundamental modulation frequencies stay constant. This would mean that the number of multiples fundamental frequency which can appear in the modulation increases and information storage capacity increases.

This kind of coding is not the only possibility and it is quite possible that entire fractal hierarchy of codings are involved such that single codeword at higher level corresponds to an equivalence class of codewords at lower level. For instance, hippocampal theta period could define the duration for the codeword of a lower level code realized by modulation using gamma frequencies. There is evidence for temporal coding in the sense that the relative temporal shift of the spike sequence with respect to the "hippocampal theta frequency" codes for the position of moving rat [**?**]. This would mean the coding of rat's position to the overall phase of the complex Fourier components representing $n > 1$ harmonics of the memetic codeword ($n = 1$ would correspond to "hippocampal theta frequency") and can be understood if the motion of rat is coded to periodically

occurring nerve pulse patterns inducing reset of theta oscillator.

4. Schizophrenic as a modern bicameral?

Schizophrenic is regarded by Jaynes as a modern bicameral. According to Jaynes, schizophrenics seem to have amazing ability to tolerate pain and to work hardly for long times without experiencing fatigue. For instance, catatonics can stay in same bodily posture for hours. Perhaps this is due to the fact that they do not experience pain in same sense as normal persons do. Jaynes also explains by this the architectural feats of ancient civilizations impossible for modern man using the primitive tools available for bicamerals.

Our emotions are partially generated by the feedback loop in which the lower level emotions expressed by the limbic brain are perceived by the cortical levels and amplified and in turn affect limbic brain. If this loop is not working properly (say due to the inhibited emotional expression), nociception is not accompanied by the experience of pain. If the transition to modernity meant also evolution of emotions and their expression, the emotional expression of bicamerals must have been primitive so that this loop cannot have been so effective as it is in the case of modern man. One can also consider the possibility that bicamerals spent a considerable fraction of time in semitrance in which regions of the emotional right brain were entangled with higher level selves or with large selves and were thus unconscious and unable to feel pain. The myth about exile from paradise would reflect that the newly developed ability to experience strong emotional pain.

Schizophrenics have often also unusually high sensory acuity: this is probably due to the weakened sensory censorship eliminating from sensory landscape unessential features. The fact that the attention of schizophrenic is more easily distractable is also consistent with this.

5. Child as a small bicameral?

Scaling law suggests that child is during the first years of her life more or less the modern counterpart of the bicameral man of Jaynes [**?**] receiving commands and advices of the higher level selves as sensory, in particular auditory hallucinations as suggested in the chapters [K86] and [K87]. Semitrance hypothesis is consistent with the fact that REM occur during wakefulness and sleep. REM is also found to occur few moments after an infant begins to engage in nutritional sucking. Even modern man has day dreams with the same 90-120 minute period as he has REM period during sleep. That small children comment their activities from third person view (*"Now John is going to do this"*) is consistent with semitrance hypothesis.

Delta wave dominance of EEG (see below) is indeed consistent with the hypothesis that child spends long times at transpersonal levels of consciousness seeing her body with eyes of outsider. The fact that the speech of child however lacks much of the emotional component present in the speech of adult is consistent with the idea that emotional expression develops gradually more refined when also generalized sensory experience about state of body becomes more refined. It has been indeed noticed already by Rousseau that child's speech lacks much of the emotional color involved with the speech of adults.

It is known delta band dominates during childhood and that the EEG intensity in delta band is reduced during aging. A possible interpretation is that the attention is during childhood more directed to transpersonal levels and gradually shifts to more bodily level (perhaps for the simple reason that the unpleasant side effects of ageing require more and more attention to the state of body!). This would suggest that aging could but need not mean spiritual degeneration. The shift to higher frequencies could mean that higher harmonics of the cyclotron frequency in delta band begin to dominate. On the other hand, sensory acuity gets poorer when individual gets older. This could have purely anatomical reasons but could also involve gradual increase of the average cyclotron frequency associated with the quale so that also harmonics of low cyclotron frequencies responsible for high sensory acuity tend to disappear from EEG. Also the timing accuracy of the temporal patterns of nerve pulses could become worse during aging. As a consequence, the frequencies of EEG waves would not be sufficiently near to the harmonics of low cyclotron frequencies anymore.

6. The role of Earth's magnetic field in the evolution of civilization?

The fundamental frequencies associated with exotic super-symplectic representations are constants of Nature. As far as the proposed role of these frequencies is considered, this is very satisfying feature. Many basic frequencies associated with exotic super-symplectic representations in EEG range are however very near to Schumann frequencies (inversely proportional to the cir-

cumference of Earth) and to important cyclotron frequencies proportional to Earth's magnetic field. This suggests the possibility of a resonant interaction so that the value of Earth's magnetic field could have played important role in the evolution.

During last thousand years Earth's magnetic field has reduced by a factor of one half. For instance, the cyclotron frequency of Co^{++} ion (probably closely involved with 10 Hz bio-clock in pineal gland), which is 10 Hz for present value of about $.5 \times 10^{-4}$ Tesla of Earth's magnetic field, has reduced by a factor two during this period. The considerations of the chapter [K57] raise the question whether the reduction of the magnetic field might have something to do with the exponential evolution of the civilization during this period.

8.6.4 Scaling Law And Sensory Maps

The vision about sensory maps realized using magnetic canvas outside the body inspires the hypothesis about a hierarchy formed by the primary and secondary sensory organs inside brain with levels labelled by the p-adic length scales. The radius of the approximately spherical structures from which the radial magnetic flux tubes serving as magnetic canvas emanate should be roughly given by the relevant p-adic length scale L. ELF MEs define the projection of the sensory image from the (possibly secondary) sensory organ to the magnetic canvas by place-frequency coding. This requires that the thickness of the magnetic flux tube depends weakly on the distance from the projecting sensory organ. A stronger assumption is that the magnetic structure serving as a sensory canvas has the same size as EEG MEs: $L_e(magn) \sim L_e(EEG)$. Hence sensory images would be magnetic giants in TGD framework whereas in standard neuroscience they would be miniatures defined by the cortical neural activity patterns.

By scaling law the sizes $L_e(EEG)$ of ELF selves relate to the sizes L of brain structures: $L_e(EEG) = (c/v)L$. Here v is the velocity of motion of EEG ME along axon, or equivalently nerve pulse conduction velocity, and f is the EEG frequency. The consistency with the scaling law is achieved if secondary sensory organs, which could be approximately spherical structures analogous to eyeball, have radii $L \sim v/f$ approximately given by various p-adic length scales $L = L_p$. As will be found later, the resulting sensory hierarchy correlates nicely with the brain anatomy, with the band structure of EEG and with the structure of the periodic table.

It is of interest to apply the scaling law at the level of eye. Amazingly, the sizes of the lense (about $L_e(191) \simeq 1$ cm) and retina (about $L_e(193) \simeq 2$ cm) are just at the lower bound of the p-adic length scale range allowing the EEG frequency to be in the range of cyclotron frequencies in Earth's magnetic field. For $v = 3$ m/s, which is the lower bound for the velocities of alpha waves, $f = v/L$ gives proton cyclotron frequency $f_c = 300$ Hz for lense size $L \sim 1$ cm and deuterium cyclotron frequency $f_c = 150$ Hz for retina size $L \sim 2$ cm or more naturally proton cyclotron frequency for a two times larger value of Planck constant. Note that higher harmonics cyclotron frequency are possible even if the lowest one is not and could thus allow deuteronic cyclotron consciousness. For retina $v = 6$ m/s gives proton cyclotron frequency for retina. He_4 consciousness would require $v \sim 1.5$ m/s, which is possible only for unmyelinated axons: the axons from retina are myelinated.

Thus it seems that the lowest level or perhaps even two lowest levels of visual consciousness could be possible at the level of lense and retina. The size of the pupil correlates with the state of consciousness. An interesting question is whether these two levels of retinal consciousness could correlate with the size of pupil. For instance, the velocity of nerve pulse conduction in the axons from retina could correlate with the size of the pupil. Contracted pupils might correspond to the most primitive form of retinal consciousness and dilated pupils to consciousness with the value of Planck constant which is two times larger. The projection to the exterior world would be determined by the input from the next level of the visual hierarchy and would be directed backwards rather than to the visual field of the retina. Retinal visual selves could thus represent the lowest level of the visual self hierarchy above EEG and would be unconscious to us as also 40 Hz visual consciousness at the primary sensory areas seems to be. What is encouraging is that the size of retina fits nicely with the general vision about hierarchy of visual selves starting already at the level of the primary sensory organ.

The lowest level in the hierarchy of the sensory consciousness would correspond to electron with cyclotron frequency $f_c \simeq 6 \times 10^5$ Hz in Earth's magnetic field. The size of the projecting organ would be about 5 micro–ns for the minimal value of $v = 3$ m/s of alpha wave velocity. This would suggest that even neurons can represent sensory input on the magnetic canvas and have senses just

k(bio)	191	193	97_2	197	199	101_2 (67_3)
$L_e(k(bio))/cm$	1	2	2.8	8	16	45 (32)
$k(ELF)$	2_2^5	251	127_2	$2^8 = 256$	257	131_2
$f(k,n)/Hz$	40.0	28.2	10.0	5.0	3.5	.63
sensory area	I	I	II	III	IV	V
EEG band	gamma	beta	alpha	theta	delta	delta
period	He	He	Ne	Ar	Kr	Xe

Table 8.3: Table gives the correspondence between biological and ELF length scales suggested by $v = L_e(k)f$ relationship assigning to the "biological" length scale $L_e(k(bio))$ (not larger than body size) ELF frequency $f(k,n)$ and corresponding "cultural" p-adic length scale, which is of order of Earth circumference for 8 Hz EEG frequency. Also the proposed assignments of the sensory areas of neocortex to these length scales are given. The lower index associated with the exponent k tells whether the scale is secondary or tertiary in the case that it is not primary (one has $p \simeq 2^k$ by p-adic length scale hypothesis).

as we do. TGD neurons would be considerably more complex creatures than the fire-doesn't fire neurons of computationalist. This is of course what fractal self hierarchy predicts on completely general grounds. From the scaling law the size of the neuronal sensory image represented by electronic magnetic transitions would be of order 10^4 meters. A possible test for this view is whether radiation at electron's cyclotron frequency or its multiples has direct effects at neuronal level.

8.6.5 Does The Structure Of Neocortex Correlate With TheHierarchy Of P-Adic Frequencies?

p-Adic frequencies differing by appropriate scalings by a power of square root two would correspond naturally to the brain structures and organizational hierarchy of brain and CNS. The nice aspect of this hypothesis would be universality and prediction of the cognitive codes.

The $v = Lf$ scaling law described earlier implies the existence of a mapping

$$L_e(k(bio)) \to L_e(k(ELF))$$

between biological length scales $L_e(k(bio))$ and cultural length scales $L_e(k(ELF))$. The mapping means that ELF self characterized by $k(ELF)$ receives sensory input from corresponding biological length scale $L_e(k(bio))$ and presumably has corresponding biological selves as sub-selves. This mapping is illustrated in the table below. For instance, the selves at length range 8-16 cm corresponding to the size of brain hemisphere and to tertiary sensory areas are scanned by ELF selves at theta frequencies.

By $L = v/f$ correspondence the structures of neocortex correspond to definite ELF selves containing at least the p-adic length scales $L_2(2^5)$, $L_e(251)$, $L_2(127)$, $L_e(2^8)$, $L_e(257)$, $L_2(131)$, ... with fundamental Super Virasoro frequencies $f(k,n)$ equal to 40 Hz, 28.2 Hz, 10 Hz, 5.0 Hz, 3.5 Hz, .63 Hz, ... Note that the fundamental frequencies correspond to gamma, beta, alpha, theta and delta bands. The table below provides a concise summary of the proposed correspondences. The length scale $L_3(83)$ corresponds to $f(1,0) = 56$ Hz contained also in the EEG range and is not given in the table.

8.7 Consciousness As A Phenomenon In The Operational Architectonics Of Brain Organization: Criticality And Self-Organization Considerations

I received an interesting article by brothers Fingelkurts (Andrew and Alexander) and Carlos Neves to be published in Chaos, Solitons & Fractals [**?**]. The title of the article is *Consciousness as a phe-*

nomenon in the operational architectonics of brain organization: Criticality and self-organization considerations.

Already on basis of the title it is clear that article is interesting also from the point of view of Topological Geometrodynamics (TGD) (see `http://tinyurl.com/yccb73gq`) (for overview see "Topological Geometrodynamics: an Overview" at `http://tinyurl.com/y7v6z4vm`) [K110], especially the part II), where quantum criticality replaces thermodynamical criticality as a basic characteristic of the Universe dictating uniquely the dynamics fixing the geometry of the "world of classical worlds" (WCW [K21], see `http://tinyurl.com/ycqyk49f`) consisting of 3- surfaces in certain 8-dimensional space-time. Quantum criticality is also central in TGD inspired theory of consciousness and the basic picture is roughly the same as in OA model. The chapter Comparison of TGD Inspired Theory of Consciousness with some Other Theories of Consciousness (see `http://tinyurl.com/yaq75hg6`) [L12] might help to get an overview about TGD inspired theory of consciousness.

Quantum self-organization (see `http://tinyurl.com/y8wcl3lm`) [K17] is second key element of TGD inspired theory of consciousness and corresponds to a cascade of quantum jumps proceeding from level of given causal diamond (CD) defined as intersection of future and past directed light-cones of 4-D Minkowski space to shorter scales (sub-CDs, their sub-CDs, etc..). Quantum jump corresponds to a state function reduction at either boundary of CD and have interpretation as sensory perception and motor action (time reversed sensory perception). CD is identified as geometric correlate for "spotlight of consciousness".

In the following I summarize the basic concepts and ideas of the article and compare them with TGD approach to consciousness. There is also a section devoted to quantum criticality in TGD Universe. The approach is certainly TGD centred and I can only apologize this.

8.7.1 The Model For Operational Architecture Of Brain (OA)

In the following I summarize my understanding of OA model by comparing in with TGD approach to consciousness.

Basic philosophy

Concerning physics, the proposed model is necessarily conservative. Non-physicist - and I am afraid that also physicist - proposing theory of consciousness hardly has any other option. The model is basically thermodynamical: no quantum effects are considered although the general structure of the model can be considered also in quantum framework by allowing macroscopic quantum effects and replacing criticality and self-organization with their quantum counterparts. The vision is roughly the following.

1. *Spatiotemporal separability stating that two regions with space-like separation are un-correlated.* This assumption is natural if one believes that classical physics is all that is needed. In quantum field theory (QFT) this corresponds to micro-causality and assumption of point-like particles. In quantum theory entanglement challenges this assumption. This assumption does not make easy to understand the unity of consciousness and the coherent behaviour of living organisms.

   TGD approach differs here from the proposed one. Point like particle is generalized to 3-surface and the notion of topological field quantization brings in the notions of field body and magnetic body. Magnetic body becomes the intentional agent using biological body to its purposes. Magnetic flux tubes serve as correlates for directed attention and for negentropic entanglement (see **Fig.** `http://tgdtheory.fi/appfigures/cat.jpg` or **Fig. ??** in the appendix of this book) and bind disjoint systems to single quantum system in some degrees of freedom.

2. *The neuro-physiological state of brain (extracellular electric fields reflecting themselves via EEG)* is in 1-1 correspondence with the contents of phenomenal consciousness. Therefore the approach is materialistic. Phenomenal consciousness is not however doomed to be illusion (whatever this could mean) and is even allowed to have causal powers. Strong emergence (system has qualities not directly traceable to those of component systems) seems to be the

philosophical characterization of their approach. Therefore the main criticism that can be made against the theory of Fingelkurts *et al* is that both phenomenal consciousness and causal powers emerge in miraculous manner as Revonsuo puts it. In TGD Universe the space-time sheet containing the smaller space-time sheet is something which does not reduce to the properties of the smaller space-time sheets.

Macroscopic quantum effects are not considered, which I take to mean that quantum statistical determinism holds true. In this framework it is difficult to understand the non-determinism accompanying the causal powers of consciousness. The proposal seems to be that thermodynamical phase transitions are the source of causal powers.

Even classical thermodynamics assigns to thermodynamical fluctuations at thermodynamical criticality certain kind of non-determinism: the motivation is the simple fact that experimentally this seems to be the case. Theoreticians must be in this kind of situation slightly illogical! Quantum non-determinism in microscopic scales might explain the non-deterministic features of critical systems extremely sensitive to fluctuations, even quantum fluctuations. If hidden macroscopic quantum coherence assignable to dark matter is present, the reduction to quantum level looks even more plausible. In TGD Universe dark matter identified as a hierarchy of phases with arbitrarily large effective value of Planck constant might be therefore also behind the long range fluctuations at thermodynamical criticality. Certainly these phase are crucial for biology in TGD Universe.

3. *Consciousness is localized to brain.* This includes also sensory qualia. This identification has well-known problems. First, the term "consciousness" is problematic since strictly speaking "-ness" implies that "consciousness" refers to a property of system: this leads to problems unless one is ready to accept materialism (in TGD approach consciousness is in quantum jump, between two worlds rather than in the world or a property of the world). Secondly, the localization of conscious experience in space-time is a problematic assumption: a weaker assumption is that the contents of conscious experience *is about* some region of space-time (causal diamond in TGD approach). Thirdly, even the localization of contents of conscious experience to brain only is problematic (sensory qualia). A weaker assumption is that only reflective consciousness consisting of recognition of objects of perceptive field and naming them and producing a representation of the external world and self in this manner is *performed* by brain (and by magnetic body in TGD context). Brain could be seen as a manufacturer of standardized mental images - representations - and phenomenal consciousness would correspond to sensory qualia. In TGD framework it is also possible to assume that sensory receptors are the seats of sensory qualia: neurons could serve as seats of qualia not conscious-to-us since selves form a hierarchy.

   One can consider even the possibility that sensory organs generate quantum entanglement with the target of attention by reconnection of flux tubes of the magnetic bodies so that perceiver and perceived form a single quantum coherent system. This would explain among other things the 3-D character of sensory perception requiring complicated neural computation if strictly 2-D data at retina is used to build the perception as a virtual world representation of the external world.

4. *Consciousness consists of a discrete series of mental images assignable to sharp phase transitions between thermodynamical far from equilibrium states.* There is a neuro-scientific support for this belief and the pleasant news is that it is just what TGD predicts via the identification of quantum jump as a moment of consciousness.

Basic ingredients of the model

Consider now the basic ingredients of the model.

1. *Living matter as open self-organizing thermodynamical system.* Energy flows through the system and gives rise to self-organization patterns with dissipation serving as a Darwinian selector taking care that very many initial states lead to the same final self-organization patterns. Second law translating to minimization of free energy is the essential element of the model.

In TGD framework self-organization is replaced by 4-D self-organization for quantum superpositions of space-time sheets leading to asymptotic spatio-temporal rather than only spatial patterns accompanied by standardized mental images. EEG pattern would be one example of this. The 4-D self-organization has also 3-D counterpart since space-time evolution represents space-time correlate for dissipation. The new prediction is that the arrow of embedding space geometric time of the resulting zero energy state is opposite in subsequent state function reductions at opposite boundaries of given CD.

Negentropy Maximization Principle (NMP) [K61] states that the information contents of conscious experience is maximal. This requires a more detailed explanation.

(a) In TGD framework state function reduction taking place in quantum jump means a measurement of subsystem density matrix leading to an eigen-space of density matrix. Hence the final state density matrix is $N \times N$ unit matrix with a degenerate eigenvalue $P = 1/N$ giving entanglement probabilities. These probabilities are rational numbers belonging to the intersection of reals and p-adic number fields Q_p. One can therefore assign to the resulting entangled state information measure that I call number theoretic entanglement entropy obtained from Shannon entropy by replacing logarithms of probabilities with p-based logarithms of the p-adic norms of probabilities. If the p-adic prime p divides N, the entropy is negative and maximum for the largest prime power factor of N: this assigns a unique p-adic prime to the final state.

(b) The proposal is that quantum jumps between real and p-adic states creating cognitive representations correspond to transitions transforming real state to p-adic one with this particular p-adic prime to satisfy NMP [K61]. The interpretation is that the state pairs in the superposition of state pairs represent instances of a rule. This negative entropy should not be confused with thermodynamical entropy which characterizes the lack of information about a member of ensemble.

(c) The systems with degenerate density matrix are clearly very special systems - quantum critical in well-defined sense- and the proposal is that the hierarchy of effective values $\hbar_{eff}/\hbar = N$ of Planck constants corresponds to this kind of systems. This hierarchy would be identifiable in terms of N-furcations of space-time surface made possible by the failure of the strict determinism of Kähler action serving as the variational principle dictating the dynamics of space-time surfaces.

(d) Clearly, several ideas are unified: quantum criticality as a presence of N degenerate states realized by space-time sheets of N-furcation, negentropic entanglement with N-fold degeneracy, hierarchy of Planck constants $\hbar_{eff}/\hbar = N$, and the idea about life as something in the intersection of real and p-adic worlds ($p = 1/N$ is rational number). Furthermore, the measurement of density matrix automatically leads to exact criticality. In dynamics without state function reduction criticality is approached only asymptotically. Note that in self-organized criticality [B2] the criticality corresponds to a minimum of potential with some flat directions in which the situation is non-deterministic at criticality.

Second law holds true also in TGD framework for (ordinary) matter, which is not negentropically entangled and is implied by the non-determinism of state function reduction at the level of thermodynamical ensemble. NMP however governs the quantal behaviour of dark matter crucial for the generation of negentropically entangled systems responsible for various representations as approximate invariants under quantum jumps (by NMP) and here negentropic entanglement enters the game. For some years ago I considered the pessimistic scenario (see `http://tinyurl.com/ybg8qypx`) [L6] in which the negentropy assignable to negentropic entanglement is compensated by thermodynamical ensemble entropy. Experimentally the situation remains open since we do not have yet experimental methods to detect dark matter - and certainly not dark matter in the sense of TGD. At this moment only the evolution of intelligence and science itself could be seen as a support for optimistic scenario saving the Universe from eventual heat death.

2. *Renormalization group principle.* Thinning of degrees of freedom means reducing the measurement resolution and forgetting the un-necessary details. This gives rise to abstraction at the level of cognitive and sensory representations characterized by cognitive resolution. The higher the abstraction level, the more un-necessary details are dropped from the representation. This means that reflective consciousness has a hierarchical structure.

   In TGD framework causal diamonds (CDs) within CDs define this kind of hierarchy characterized by spatial and temporal scales defining embedding space correlate for the self hierarchy. Many-sheeted space-time serves as a geometric correlate for the hierarchical structure of consciousness.

   p-Adic length scale hypothesis makes the hypothesis quantitative and means that continuous renormalization group evolution is replaced with a discrete p-adic coupling constant evolution. Finite measurement resolution implies effective discretization at space-time and embedding space level.

   Discretization is also forced by the notion of p-adic manifold (see `http://tinyurl.com/ydxw3zvm`) [K113], whose definition forces the introduction of finite length scale and angle resolutions having number theoretic interpretations. The common rational (or even some algebraic) points of real and p-adic space-time surfaces define the discrete cognitive representations at space-time level. One can say that life resides in the intersection of reality and various p-adicities.

3. *Self-organized criticality (SOC).* The sensitivity of sandpile to avalanches serves as an illustration for self-organized criticality (see `http://tinyurl.com/65bo4k`) (SOC [B2])). A very elegant characterization of SOC is as a critical point which is an attractor but such that the matrix defined by the second order partial derivatives of potential function has non-maximal rank being thus non-invertible.

   SOC inspires the notion of neuronal avalanche. Neuron groups form synchronically firing structures which end up to criticality. At criticality a fast increase of entropy takes place (the reduction of free energy per time is maximal: eat the food as fast as possible so that others do not steal it!). After this the system uploads the entropy to environment and generates negentropy for a while later compensated by entropy. There is evidence that a sequence of neural avalanches self-organize to avalanches in longer time scale. Temporal sequences of associations representing memories and predictions would be possible interpretation.

   In TGD framework this picture has interpretation in terms of the basic fractal structure of quantum jump. In quantum jump negentropic entanglement is generated: NMP dictates this. After this follows a cascade of quantum jumps (state function reductions for sub-CDs unless they are mutually negentropically entangled) and this generates ensemble entropy because the outcome of state function reduction for ordinary entanglement is random and takes entanglement entropy to zero. The process continues and certainly ceases when all sub-CDs have internal negentropic entanglement so that nothing can happen. At least after this the state function reduction to the opposite boundary of CD occurs. Whether second law is satisfied remains an open question as already noticed.

Operational architectonics of brain

This picture combined with the decomposition of local EEG to quasi-stationary segments leads to the notion of Operational architectonics of brain.

1. *Operational architectonics of brain (OA).* The hypothesis is that neuronal avalanches represent the primary building bricks of more complex brain activities. These more complex activities are constructed as operational modules (OM) from the elementary neuronal self organization patterns. This however requires synchronous firing of neurons and the challenge is to understand how this is physically possible if one assumes that disjoint regions of 3-space do not have any correlations.

   The spatiotemporal patterns of extracellular electric fields are assumed to be in 1-1 correspondence with phenomenal experiences. Authors introduce also the notion of operational

space-time (OST) assumed to exist within internal physical space-time (IPST). These notions remain somewhat fuzzy in the framework of classical physics.

The proposed architectonics is 4- rather than 3-dimensional. The notions of 4-D brain and causal diamond (CD) as 4-D spotlight of consciousness define the counterpart for OA in TGD framework. In TGD framework OST and IPST bring in mind p-adic and real variants magnetic body and the topological light rays parallel to them.

Braiding of the short portions of flux tubes connecting bio-molecules (say tubulins and axonal membrane) serve as a geometric correlate for negentropic entanglement and negentropically entanglement subsystems give rise to various representations as "Akashic records", which are experienced consciously.

The original view, which is *not* consistent with the recent view formulation of TGD inspired theory of consciousness, was that "Akashic records" could be read by interaction free measurement modified so that one obtains holographic representation of the data readable by using reference beam [L12] (see `http://tinyurl.com/yaq75hg6`).

The recent view is that only bit representations of memories can be read by interaction free measurements. The detectors in interaction free measurement correspond to the hologram substrate analogous to excitable lasers. The cyclotron Bose-Einstein condensates of dark matter with large value of $\hbar_{eff}/\hbar$ at the "long" portions of flux tubes and large flux sheets (with size scales exceeding even the Earth's radius) carry sensory and other representation as analogous of lasers excited in the reading of the representations.

2. *The decomposition of local EEG to quasi-stationary segments.* The proposal is that the sequences correspond to self-organization patterns for neuronal assemblies and serve as correlates simple qualia. The transitions between the quasi-stationary segments are sharp and the interpretation is as correlates for the above described phase transitions: they care referred to as rapid transitional processes (RTPs).

   In TGD framework EEG (see `http://tinyurl.com/yavjeosp`) [K93] serves as a control and communication tool for magnetic body using biological body as sensory receptor and motor instrument. There is a strong temptation to assign the quasi stationary segments of EEG to self-organization patterns assignable CDs with frequency scale in 1-1 correspondence with the scale of CD (discrete). The amplitude- and frequency modulation of the Josephson radiation emitted by cell membrane acting as Josephson junction would map neural activity to temporal patterns of EEG.

3. *Neuronal synchrony binding neuron groups to operational modules.* Authors have introduced the notion of operational synchrony (OS) to describe the needed synchrony. This synchrony should be visible in EEG channels as correlations of the quasi-stationary segments.

   In TGD context OMs would be formed and destroyed by the reconnection of magnetic flux tubes building different quantum coherent structures formed from neurons. For instance, patterns defining objects of the visual field could correspond to this kind of quantum coherent units. This process would take place in all living matter and ATP-ADP transformation could generate standardized reconnection and negentropic entanglement between distant biomolecules. The basic function of metabolism would be production and modification of negentropic entanglement

8.7.2 About The Notion Of Criticality In TGD Framework

Criticality is one of the basic notions in Finglekurts *et al*'s model and has quantum criticality as TGD counterpart. As a matter of fact, quantum criticality is a fundamental physical principle of TGD dictating the classical and also quantum dynamics so that it deserves a separate discussion. The value of Kähler coupling strength - the only parameter of theory - is fixed as the analog of critical temperature. In order to characterize the critical degrees of freedom one must say something about the Kähler metric of WCW. .

Very roughly, WCW can be seen as a generalization of the loop space of string models or of the super-space of Wheeler consisting of 3-geometries. WCW consists of all 3-surfaces in the 8-D embedding space $M^4 \times CP_2$. Holography due to 4-D general coordinate invariance implies

that one can speak about WCW also as a space of 4-D space-time surfaces with space-time surface being analogous to Bohr orbit. The challenge is to generalize Einstein's geometrization of physics program and geometrize quantum physics by providing WCW with so called Kähler geometry for which the metric is characterized by single function, so called Kähler function. There are excellent hopes that this geometry is unique since already for loop spaces this is the case. The mere mathematical existence of this geometry requires infinite-D symmetries and for 4-D space-time one can indeed generalized the conformal symmetries of super string model and achieve these symmetries. WCW becomes a union of infinite-dimensional symmetric spaces for which all points are geometrically equivalent. The zero modes labelling the symmetric spaces have interpretation as non-quantum fluctuating classical variables needed in quantum measurement theory.

Consider now what criticality means in this framework.

1. The matrix defined by the second order derivatives of Kähler function with respect to WCW coordinates is degenerate as is also the WCW Kähler metric defined by a subset of these derivatives ($G_{K\overline{L}} = \partial_K \partial_{\overline{L}} K$ is the defining formula of Kähler metric in complex coordinates in terms of Kähler function K).

   The reason for the degeneracy is that WCW metric depends on real zero mode coordinates, which do not appear as differentials in the line-element. These coordinate directions of WCW correspond to non-quantum fluctuating classical degrees of freedom not contributing to WCW Kähler metric. The proposed generalization of quantum measurement theory assumes that zero modes are analogous to classical variables defining say the position of a pointer of a measurement instrument and that they are in 1-1 correspondence with the outcomes of quantum measurements in quantum fluctuating degrees of freedom and give rise to quantum classical correspondence.

2. Quantum criticality would corresponds to a situation in which maximum of Kähler function (defining most probable space-time surface in their quantum superpososition) corresponds to a Kähler metric for which some elements of Kähler metric approach zero so that the rank for the matrix defined by the non-vanishing components of the Kähler metric is reduced. The resulting degrees of freedom would be effectively zero modes inside the critical manifold but not elsewhere. The criticalities would define an infinite hierarchy analogous to the finite hierarchy of criticalities for finite dimensional catastrophes Thom's catastrophe theory (see `http://tinyurl.com/fpbsm`) [A10]: cusp catastrophe is the simplest non-trivial example.

3. At the level of conformal symmetry algebras (see `http://tinyurl.com/ycqyk49f`) [K105] defining the infinite-dimensional symmetries of TGD Universe - call them with generic name A - this hierarchy could have very elegant representation. The elements of conformal algebra are labeled by integer plus other quantum numbers so that one can write the element of algebra $a_{n,\alpha}$. Critical sub-manifolds woud correspond to sub-spaces of WCW for which the elements $a_{nk,\alpha}$ of sub-algebra A_n (k is integer) annihilate the states or creates zero norm f states from them. Here n is a non-negative integer characterizing the critical manifold. Critical manifolds would be in 1-1 correspondence with non-negative integers n. If n_1 divides n_2, the critical manifold Cr_{n_2} belongs to Cr_{n_1}.

4. In the phase transitions between different critical manifolds some quantum fluctuating degrees of freedom become local zero modes in the sense that their contribution to WCW metric at a given point of WCW vanishes at criticality. Also the reverse transformation can take place.

There are some interesting questions to be answered.

1. Criticalities form a number theoretic hierarchy and primes define "prime criticalities". Does this mean that the primes dividing integer n define the possible p-adic topologies assignable to criticality defined by n?

2. The hierarchy of effective Planck constants is labelled by integers and giving integer n corresponds to n-furcation made possible by the failure of strict determinism for Kähler action. Could this integer correspond to the integer defining the criticality? Criticality is indeed accompanied by non-determinism realized as long range fluctuations.

3. Causal diamonds have size scales coming as integer multiples of CP_2 scale. Does this integer relate to the integer defining criticality?

4. The condition that the n characterizes finite measurement resolution in the sense A_n annihilates the physical states everywhere would de-localize the critical states outside the critical manifold. Does this mean that also finite measurement resolution is characterized by integer.

5. How the 4-D spin glass degeneracy due to the huge vacuum degeneracy of Kähler action implying breaking of strict determinism relates to quantum criticality?

These connections together with those suggested by NMP suggest that integer arithmetics is coded directly to the hierarchy of criticalities and is also basic characteristic of consciousness. This would give additional piece of support for the vision about physics as a generalized number theory (see `http://tinyurl.com/y86lo57g`) [K69].

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Chapter 9

EEG and the structure of magnetosphere

9.1 Introduction

Roughly 15 years ago I proposed the idea that Earth's magnetosphere could serve as a sensory canvas in the sense that biological systems, in particular the vertebrate brain, could have sensory representations realized at the "personal" magnetic body (MB) closely associated with the magnetosphere of the Earth [K57, K55]. EEG would make communications to and control by MB possible [K38, K81].

During fifteen years a considerable progress has occurred. At that time I did not have yet the idea about the number theoretical realization of hierarchy of Planck constants $h_{eff} = nh_0$ in the framework of adelic physics fusing the physics of sensory experience and cognition [L38, L39]. This hierarchy is crucial for understanding the basic aspects of living matter such as metabolism, coherence in long scales, correlates of cognition, and even evolution.

Also the concept of zero energy ontology (ZEO) [L63] forming now the basis of the quantum TGD was missing although there was already the about communication to past using negative energy signals. ZEO is now central role in the understanding of self-organization [L62] - not only the biological one. The new view about time predicting that time reversal occurs in ordinary state function reductions (SFRs) allows to understand homeostasis as self-organized quantum criticality [L128].

For these reasons it is interesting to consider the notion of sensory canvas from the new perspective.

9.1.1 Some basic ideas of TGD inspired quantum biology

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

1. Many-sheeted space-time allows the interpretation of the structures of macroscopic world around us in terms of space-time topology. Magnetic-/field body (MB) acts as intentional agent using biological body (BB) as a sensory receptor and motor instrument and controlling the BB and inheriting its hierarchical fractal structure. The quantum coherence of MB in turn induces the coherence of biomatter.

   That MB receives sensory input motivates the idea that MB serves as a kind of sensory canvas [K57, K55]. This idea generalizes: the information received can be also more abstract information and the layers of the MB could define a hierarchy of increasingly abstract representations of the sensory data [L69, L131].

   Fractal hierarchy of EEGs and its variants can be seen as communication and control tools of MB. Also collective levels of consciousness have a natural interpretation in terms of MB.

   MB 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.

2. MB carrying dark matter as $h_{eff} = nh_0 > h$ phases of the ordinary 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.

   MB is identified as intentional agent using biological body as sensory receptor and motor instrument [K75, K74]. EEG and its fractal variants are identified as a communication and control tool of the MB 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 [K3, K2, K108]. The model of DNA as topological quantum computer is one application. In ZEO the braiding actually generalize to 2-braiding for string world sheets in 4-D space-time and brings in new elements.

3. ZEO makes possible a p-adic description of intentions and cognitions and their transformations to action. Time mirror mechanism (see **Fig.** `https://cutt.ly/DcDKyTj`) 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.

   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.

4. 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.

5. One can also understand genetic code. 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 way and vertebrate genetic code as correspondence between DNA and amino-acids emerges naturally [L21, L56]. This suggests that genetic code is realized at the level of dark nuclear physics. The chemical realization would provide only a secondary representation of the code.

   The recent findings support the view that the genetic code is actually universal and realized at the fundamental level in quantum TGD. Hitherto unknown realizations in living matterare suggestive [L77]. Second realization of the genetic code would be associated with communications using dark photons. It would be in terms of dark photon triplets defining 3-chords of light and realized in terms of icosahedral and tetrahedral Hamiltomnian cycles giving rise to a set of bio-harmonies having interpretation as correlates of emotions at the molecular level [L15, L70, L77]

9.1.2 Some questions

MB has roles as both sensory canvas and controller of the ordinary matter with standard value $h_{eff}0nh_0 = h$ using EEG and its fractally scaled variants for these purposes. This raises some questions.

Could magnetosphere be a living and metabolizing organism?

h_{eff} is a measure for algebraic complexity and analogous to IQ. h_{eff} tends to be reduced spontaneously. Metabolic energy is needed to preserve the distribution of h_{eff} and also to drive self-organization.

Could one think that MB is a higher level organism utilizing energy arriving from the Sun. Could solar radiation and solar wind provide metabolic energy to the Earth's magnetosphere (MS) accompanied by "personal" MBs. Could MB also receive metabolic energy produced by photosynthesis at the surface of the Earth?

Could the rotating inner MS transfer energy from solar radiation and transfer it to the night-side of the Earth. Could also solar wind provide energy to magnetopause, plasma pause, plasma sheet and neural sheet which are self-organizing highly dynamical structures? Could these regions of the MS serve as a sensory canvas?

Could the anatomy of the magnetosphere be regarded as a scaled variant of the anatomy of a vertebrate?

The anatomy of the MS (see the illustrations of `https://cutt.ly/kcDKzqL`) resembles that of a vertebrate. The TGD Universe is fractal and this inspires the question whether there is something deeper behind this resemblance: could the anatomy of the MS be scaled up anatomy of the organism? This would be natural if the "big" part of the personal MB assignable to the MS serves as a sensory canvas.

The correspondence need not be a strict scaling. Conformal transformations define a more general correspondence and the correspondence respecting only topology is even more general correspondence.

Could one gain useful insights by formulating this idea quantitatively? Could the scales of the body parts of the vertebrate(say human)body and MS correspond to each other at the order of magnitude level? Could the ratios of scales for the corresponding parts of the MS and human body be nearly the same?

The sensory canvas idea is discussed earlier at the level of the brain in [**?**, K55] but restricting the consideration to the cyclotron frequencies for magnetic fields involved with various parts of the MS. The distance of the part of the MS gives an upper bound for the frequencies involved with the communications between it and the biological body. Could one associateEEG bands with the parts of the MS? The frequency scale correspondence indeed predicts frequencies in EEG range and it is possible to assign EEG bands to the parts of the MS.

9.2 The structure of the magnetosphere of Earth

It is interesting to try to relate the model for sensory representations to the structure of Earth's MS. To achieve this, I will provide a brief novice's overview about the structure of MS. I will use partially TGD based language in which magnetic field lines are replaced by magnetic flux tubes and the formation of the plasma corresponds to the leakage of the supra currents from the magnetic flux tubes.

I will also briefly consider TGD based qualitative models for the phenomena, many of which are not well understood in Maxwellian theory. Examples of such phenomena are Alfven waves which are not proven to result from Maxwellian theory, and magnetic dynamo of Earth whose working mechanism is not really understood. Also the mechanism of auroras becomes very concrete when field lines are replaced with flux tubes [K19].

9.2.1 Magnetosphere

Solar wind [F4, F10, F9] determines the large scale structure of the magnetic field of Earth to a high extent. The basic structural components are transition regions and regions between them.

1. At the bow shock the solar wind arriving at a supersonic velocity of 500 km/s encounters Earth's magnetic field and is transformed to a subsonic flow and dissipates energy inside magnetosheath where the plasma is denser and hotter than in the solar wind. The distance of the bow shock is roughly 12-14 R (R denotes Earth's radius).

2. The shocked solar wind cannot penetrate Earth's magnetic field and a cavity called MS is formed. Interplanetary magnetic field and MS is separated by a transition region called magneto-pause, which is accompanied by a plasma mantle. At the day-side magneto-pause is at a distance of about 10 R but when the solar wind is particularly strong, it can move down to 6-7 R. At the night side MS is stretched into long cylindrical magneto-tail of length about 1000 R and radius about 20 R.

MS consists of clearly separated regions with widely different densities and temperatures. The main division is into the inner and outer MSs. In the inner MS (also known as plasma sphere) magnetic field lines are co-rotating with the Earth: in the outer MS they are stationary.

Boundaries are the regions at which self-organization typically occurs.

1. Magneto-pause contains an ionic current determined by the discontinuity of the magnetic field and orthogonal to it. This region is highly dynamic.

2. The boundary between inner and outer MSs is known as plasmapause. Also this region is dynamical and its shape and size varies as response to solar wind. The analog is liquid is the boundary between two compressible liquid flows: other flow is rotating and other flow stationary.

3. Outer MS consists of a plasma sheet, which is between magnetic lobes carrying magnetic fluxes, which have opposite directions and are bounded by the magnetopause. In the plasma sheet the magnetic flux flows between the northern and southern lobes to give rise to closed field lines. Neutral sheet is in the equatorial region and starts at $10 \pm 3R_E$. Also this region is dynamic.

Both magnetopause, plasma pause and neutral sheet are expected to be highly dynamical self-organizing regions and are especially interesting from the point of view of magnetospheric consciousness.

9.2.2 Outer magnetosphere

Magnetic lobes

The outer MS at the night side, magneto-tail, consist of northern and southern magnetic lobes which are cavities having very low ionic density of about.01 ions per cubic cm. The low density can be understood as resulting from the absence of the solar wind in this region. By Maxwell's equations the magnetic field is approximately constant in the region where the flow lines are parallel (if sources can be neglected). According to [F3] the value of the magnetic field is about 30 nT in the interior of the lobes. The relatively strong magnetic field inside lobes serves as a magnetic energy battery feeding energy to the plasma sheet.

Magneto-tail is a cylindrical structure with radius of order $R_m = 20R$. Magnetic lobes extend up to $r \sim 1000R$. The magnetic field lines remain actually closed. In the TGD framework this means the existence of a closed supra-current circuitry formed by the magnetic flux tubes.

Plasma sheet and magneto-pause

Magnetic lobes are separated by a plasma sheet in the equitorial plane consisting of hot (5×10^6 K), low density plasma (.3-.5 ions/cm^3 as opposed to.01 ions/cm^3 inside lobes) with magnetic field $\sim$ 10 nT. Plasma sheet extends from $8R$ to about $60R$ and has thickness of order few R, and gets thinner with increasing distance. Plasma sheet disappears at the so called neutral point, where the magnetic field vanishes. In the plasma sheet the magnetic flux from the southern lobe flows to the northern lobe. Near the Earth plasma sheet reaches the high latitude auroral ionosphere. The value of the magnetic field immediately above the magnetic sheet is 20 nT.

In the TGD framework the plasma sheet can be seen as resulting from the leakage of the supra currents from the magnetic flux tubes of Earth's magnetic field to a larger space-time sheet. This supra-current leakage would be caused by the inertia of the ions and electrons in the region where the magnetic flux tubes are highly curved. The leakage occurs also in the magneto-pause, where the tangential component of the magnetic field is discontinuous and a surface current orthogonal to B generating the discontinuity flows.

In the magneto-pause the magnetic flux tubes of the inner and outer region are parallel. The reconnection of the parallel flux tubes of the magnetic fields of Earth and Sun allows the transfer of the ions of the solar wind to the MS. Magneto-pause is accompanied by a plasma mantle, which could be partially due to the leakage of ions to a larger space-time sheet accompanying the reconnection process.

There is a convective flow of ions towards the plasma sphere along the plasma sheet. In the TGD framework this motion must take place at a larger space-time sheet or involves a hopping between magnetic flux tubes: in both cases a breaking of the propposed super-conductivity is implied.

Plasma sheet also has a boundary layer in which the tangential component of the magnetic field is discontinuous. This requires a surface current orthogonal to the axis of the sheet. This current would result as the ions from the magnetic flux tubes leak out from flux tubes to a larger space-time sheet by their inertia in the highly curved portion of the flux tube caused by the tangential discontinuity.

Cusps

Southern and northern cusps are funnel-shaped regions which on the day side consist of closed highly compressed flux tubes of dipole field and on the night side of almost open flux tubes stretched deep into the magnetospheric tail. In this funnel magnetic field is orthogonal to the magneto-pause and the magnetic flux tubes of the solar magnetic field can penetrate the MS. This implies that solar plasma contained in the solar magnetic field lines penetrates deeply into the magneto-tail by reconnecting with the field lines of Earth's magnetic field near poles. This gives rise to auroras [F11].

Reconnection can be seen as resulting from the penetration of the solar magnetic flux tubes at the upper boundary of the magneto-pause along the plasma sheet to highly stretched flux tubes along the boundary of the plasma sheet. The transformation to open flux tubes can happen only if the solar flux tubes reconnect with the flux tubes of the solar magnetic field penetrated into the plasma sphere. Thus auroras can be seen as a phenomenon involved with the boundary between plasma sheet and lobes.

Cusps, and to some extent also plasma mantle, serve as a channel along which the solar wind feeds "magnetometabolic" energy to the MS needed to run the geodynamo system [F1] (the notion of super-conducting geodynamo will be introduced later). The dipole field generated solely by the convective currents in Earth interior would die out in a few thousands of years. The field inside lobes serves as a storage of magnetic energy and is recharged by the energy of the solar ions leaking into the magnetic tail in the reconnection process. One could see the cusps also as a communication channel between solar and Earth's magnetic structures, kind of magnetic "ears" of magnetic Mother Gaia.

9.2.3 Basic structure of the inner magnetosphere

Inner MS is a toruslike structure whose extension varies between 4R (day side) and 8R (night side). In the inner MS the typical density is about 1 ion per cubic centimeter.

Inner MS is bounded by a transition layer of thickness of $\sim R$ (magneto-pause). In this region the density of the ions drops rapidly.

Inner MS contains plasma sphere whose radius varies in the range 2R-4R at day side and 2R-6R at night side. Plasma has an ionospheric origin. The density of the cold plasma consisting mainly of protons ($T \sim 1$ eV) sphere varies in the range $10 - 10^3$ ions/cm^3, whereas the temperature is $\sim 5 \times 10^3$ K. The cold, dense plasma of the plasma sphere is frozen around magnetic flux lines which co-rotate with Earth.

In the TGD framework this means that flux tubes co-rotate and thus change shape. In the equatorial plane the density of the plasma sphere drops sharply down to ~ 1 ions/cm^3 at $r = 4R$. This transition region is known as a plasma pause. During magnetic storms the outer radius decreases since the pressure of the solar wind compresses the plasma sphere. The day-night variation of the shape of the plasma sphere is rather small. Within this region the magnetic field in a reasonable approximation has dipole shape with radiation belts forming an exception.

9.2.4 Radiation belts and ring currents

Plasma sphere (i.e. inner magnetosphere) contains the inner and outer van Allen radiation belts [F2] (extending from $2R$ to $4R$ at the day side and from $2R$ to $9R$ at the night side).Inner radiation belt extends from distance $.2R_E$ to $2R_E$. Outer radiation belt extends from distance $3R_E$ to $10R_E$ and is regarded as part of non-rotating outer MS. Both the inner and outer belts extend up to latitude of 60 degrees. The boundaries of the belts follow magnetic field lines except at the Northern and Southern tips. This region contains ring currents.

One of the functions of the radiation belts is to prevent the penetration of the biologically harmful high energy cosmic rays to the ionosphere. In fact, the inner protonic belt results from the decay of the cosmic ray neutrons to protons. Second function (in TGD universe!) is to act as a part of a controlled dynamo system giving rise to the MS of Earth (for the standard theory of geodynamo see [F1]).

It has been found that the energies of the ions in the radiation belts are much higher than one might expect [F5]. This might be understood if part of the ions runs as supra currents along the magnetic flux tubes. Super-conductivity is broken only by the leakage of the supra currents from the magnetic flux tubes. This could explain the success of magnetohydrodynamics based on the assumption of effective super conductivity.

Inner radiation belts

There are actually two separate inner radiation belts: the one containing protons and the one containing electrons. Protons in the inner belt have energies at 10-100 MeV range and readily penetrate space crafts. The inner radiation belts are concentrated around the equator in the range $(1.1 - -3.3)R$ (these numbers depend on the conventions used and should not be taken too literally). In the protonic belt the maximum of the flux density is at $2R$: in the electronic belt the maximum flux density is at about $1.4R$. The inner belts are relatively stable and there is no night-day difference. The inner belts feel magnetic storms and vary with the 11 year period of solar activity.

What is interesting is that the inner belts are also sensitive to human technology. The inner belt has lowered above the East Coast of US from 300 km to 10 km [**?**]: this process is associated with power transmission along magnetic field line and the usage of the ionosphere-resonance frequency 60 Hz as the frequency of household current.

During the last decade two new belts have formed inside inner belts [F4], [**?**]. The new electronic belt has maximum electron flux at $r \sim 2R$ (earlier flux maximum was at $r \sim 1.4R$). The second newcomer consists mostly of O^+ ions but contains also He^+. This process has been seen as a part of magnetic re-self-organization process occurring in the scale of the entire helio-magnetosphere implying rapid changes of planetary MSs [**?**].

Outer radiation belt

Outer belt contains mainly electrons with energies up to 10 MeV and is produced by the injection of charged particles during geomagnetic storms. This makes the outer belt much more dynamical than the inner one. The cross section of the outer radiation belt is banana shaped. The outer belt ranges from 3R to 6R (at night side). The maximum for the density of electrons above MeV energy occurs at 4R.

Ring currents

Radiation belts contain ring currents. Electronic ring current rotates in the same direction as Earth whereas protonic current runs to the opposite direction. In the outer belt only electronic current is present. Quiet time ring current in the inner electronic *resp.* protonic belts consist mainly of hydrogen ions resp. electrons but during magnetic storms also O^+ ions are present (note however the presence of the new O^+ belt). Ring current has the effect that the magnetic field gets stronger at the outer side of a given belt and weaker at the inner side.

9.3 Frequency scales associated with the magnetosphere

9.3.1 Cyclotron frequencies in magnetic lobes and plasma sheet

The values of important magnetic transitions frequencies in various regions of the MS are crucial if one wants to construct a general vision about sensory and motor representations at the magnetic sensory canvas. In the inner MS dipole approximation allows to estimate the spatial dependence magnetic transition frequencies.

In magnetosheath and magnetolobes the average values of the magnetic field are 10 nT and 30 nT respectively. Immediately above the magnetosheath the value of the magnetic field is 20 nT. Magnetosheath could thus allow place coding by the magnetic transition frequency scale whereas magnetolobes are not taylor made for this purpose. Note that the thickness of the magnetic flux tubes in the field of 10 nT $= 2^{-9}B_E$, $B_E = 5 \times 10^4$ nT is from the quantization of magnetic flux equal to about 55 μm and thus corresponds to a biological length scale. This length scale corresponds to the p-adic length scale $L(11, 16)$ ($L_p(n) = p^{(n-1)/2}L_p$). Already this encourages to think that plasma sheet might be involved with bio-control.

The strength of the interplanetary magnetic field depends on the intensity of solar wind and varies between $.2 - 80$ nT and has average of 6 nT. Interestingly, the maximum value 80 nT corresponds to the p-adic length scale $L(173) = 20$ μm.

1. Proton

In the case of proton there are three especially interesting frequencies to be considered: cyclotron frequency $f_c = eB/2\pi m_p$, spin flip frequency and the frequency of combined spin flip and $\Delta n = 1$ transitions. The frequencies of these transitions in magnetic field of $.5 \times 10^{-4}$ T are $f_c = 300$ Hz, $f_{flip} = 838$ Hz, $f_1 = 532$ Hz and $f_2 = 1138$ Hz. In a field of 10 nT the values of the transition periods $T = 1/f$ are $T_c = 16.7$ sec, $T_{flip} = 6$ sec, $\tau_1 = 9.3$ sec, and $\tau_2 = 4.4$ sec. For a field of 30 nT the values are obtained by dividing by three. Plasma sheet contains also He^{++} and He^{+} ions and for these the cyclotron times are 2τ and 4τ. For O^+ ion which is also present cyclotron time varies between 1 min 20 s and 4 minutes. All these time scales are typical time scales of human consciousness. For the interplanetary magnetic field protonic cyclotron times are 13.9 min, 27.8 sec, and 2.1 sec for the minimum, average, and maximum respectively.

2. Electron

For electrons the cyclotron frequency is 282 Hz for 10 nT so that electronic cyclotron transitions cannot represent ionic cyclotron transitions in brain (if they occur at the flux tubes of Earth's magnetic field!). Spin flip combined with cyclotron transition represents however an important exception. In this case the non-vanishing transition frequency is due to the anomalous magnetic moment of electron and the frequency in the reference field of $.5 \times 10^{-4}$ T is 2255 Hz. This gives $T(e) = 2.24$ sec. Note that also $n = 3$ protonic cyclotron transition gives rise to nearly the same period.

It is interesting to notice that these time scales are important time scales of human consciousness and that both protonic spin flip time scale and $T(e)$ nearly half of the 5 second time scale associated with the Comorosan effect [I77, I18] discussed in [K114]. If Earth's magnetic field is accompanied by dark flux sheets in entire MS carrying field $B_{end} = 2B_E/5$, then the value of $T(e)$ would become $T(e) = 5$ seconds for $B_E = 11.2$ nT.

To sum up:

1. The average magnetic field in plasma sheet corresponds to a definite p-adic length scale.

2. The mysterious time scale of the Comorosan effect pops up as a basic magnetic transition time in magnetic lobes and plasma sheet and is related to bio-control by enhancing catalytic rates: it is however essential that the "dark" counterpart $B_{end} = 2B_E/5$ of B_E associated with living matter is in question.

3. Plasma sheet is found to be a complex self-organizing system with the velocity distribution of ions representing complex features (such as "eyes" and "wings" !) [F7].

These findings force to seriously consider the possibility that plasma sheet and magnetopause and perhaps even magnetic lobes might perform high level bio-control utilizing MEs and

Region	R/R_E range	f/Hz range	EEG bands
plasma sheath	...-1000	...-0.049 (20 s)	
inner MS	1-10	49.0-4.9	$\theta, \alpha, \beta, \gamma$
plasmapause	4.0-5.0	12.5-10.0	θ, α
inner van Allen belt	.2-2.0	75.0-7.5	θ, β, γ
outer van Allen belt	3.0-10.0	5.1-1.5	δ
day-side magnetopause	8.0-10.0	6.25-4.9	θ
night-side magnetopause	10.0-200.0	4.9-.2 (5 s)	δ
plasma sheet	10.0-60.0	4.9-.82	δ
neutral sheet	7.0-13.0	7.0-3.8	δ

Table 9.1: The frequency scales f assignable to the size scales R of various regions of the MS (MS)

supra-currents along magnetic flux tubes forming the extension of the endogenous magnetic circulation to the entire MS.

9.3.2 Estimates for the natural frequency scales assignable to various parts of the magnetosphere

The part of MS having distance R from the center of Earth corresponds naturally to frequency scale $f = 1/R$. This allows a rough estimate for the frequencies needed for the communications between various parts of MS. What is highly non-trivial is that these scales are in EEG range and that one can even assign EEG bands to the regions of MS.

The basic correspondence is given by the formula $f = 1/R$: favored frequencies are harmonics of this fundamental frequency. Takin the Schuman resonance frequency 7.8 Hz as reference and Earth radius as length unit, one has

$$\frac{f}{Hz} = \frac{R_E}{R} \times 2\pi \times 7.8 = \frac{R_E}{R} \times 49$$

Table 9.1 summarizes the frequency scales assignable to the size scales of various regions of the MS.

Some remarks are in order.

1. Plasmapause corresponds to frequency range 10-12.5 Hz containing alpha band and also frequencies often included in theta band.

2. Neutral sheet corresponds to the range 3.8-7.0 Hz above delta band.

3. The outer van Allen belt corresponds to delta band in EEG. Therefore also the delta band of EEG dominating during deep sleep appears naturally also at the day-side. Note that outer van Allen belt belongs to the non-rotating outer magnetosphere.

4. Night-side magnetopause and plasma sheet contain frequencies in delta band which dominates during deep sleep.

5. The lower bound for frequencies from the size of magnetopause at night-side corresponds to the period 5 s assignable to the Comorosan effect [I77, I18] [K114].

6. Day-side regions of the MS correspond to θ, α, β and γ bands.

These findings encourage to ask whether the communications between the brain (and possibly also other parts of body, at least central nervous system) and MS could be in terms of EEG.

Region	$y = R/R_E$ r	r
Earth	1.0	3.5 mm
plasmapause	4.0-5.0	1.4-1.7 cm
inner van Allen belt	0.2-2.0	.84-7.4 mm
outer van Allen belt	3.0-10.0	1.3-4.2 cm
day-side magnetopause	8.0-10.0	2.8-3.6 cm
night-side magnetopause	10.0-200.0	3.6-80.0 cm
plasma sheet length	10.0-60.0	3.6 cm-21.5 cm
plasma sheet thickness	5.0-10.0	1.8 cm-3.6 cm
neutral sheet	7.0-13.0	2.4-4.6 cm

Table 9.2: The scaled down radii $r = .5 \times 10^{-9} R = y \times 3.5$ mm for various regions of the MS (MS) with radius $R = yR_E$

9.3.3 Could one regard magnetosphere as a scaled variant of biological body?

Sensory canvas hypothesis allows two options. MS could be the sensory canvas for the brain or for the entire nervous system and body. The structure of the MS suggests that it could correspond to a sensory map of the entire body.

1. Inner MS could be the sensory canvas for the brain or part of it and Earth perhaps to some nucleus, say pineal gland.

2. Magnetopause would correspond to skin and magnetic lobes would correspond to to the interior of the body. Plasma sheet would correspond to the interior of the body and the neutral sheet at which the direction of magnetic field changes to the spine.

3. Left and right body parts would correspond to northern and southern magnetic lobes.

4. The inner MS could correspond to the part of the nervous system assignable to the head and neck and involve cranial nerves associated with vision, hearing, and smell. Outer MS could correspond to tactile senses.

5. The neutral sheet at the night side of the outer MS could correspond to the spinal cord, which has dorsal and ventral parts which could correspond to flux tubes with opposite fluxes.

6. Plasma sheet would contain the spinal nerves leading to the magnetopause as the counterpart of the skin.

The frequency-distance correspondence suggests a rather detailed correspondence between EEG bands and magnetospheric regions. Delta band dominating during deep sleep should correspond to the magnetopause, plasma sheet, and neutral sheet.

A quantitative formulation for this hypothesis is in terms of fractality. The scales of the body and corresponding parts of the MS should be in constant proportion and the ratios of the corresponding scales should be the same for body and MS.

Magnetopause has thickness $D \simeq 1000$ km. Magnetopause corresponds to skin and the first guess is that the ratio of smallest and largest length $L = 200R_E$ associated with the MS has same value as the corresponding ratio for human body. One has $D/L = 1340$. The ratio the human body length $l \sim 1$ m of the human skin thickness $d \simeq .5$ mm is $l/d = 2 \times 10^3$. The order of magnitude is same. $D/L = 2 \times 10^3$ would give a perfect fit.

$R_E = 6.37D$ and the ratio $x = d/D = .5 \times 10^{-9}$ allows to scale down various scales $L = yR_E = 6.37yD$ of MS to $xL = y \times 3.5$ mm to see whether they are consistent with the corresponding scales of body suggested by the above intuitive considerations.

Table 9.2 summarizes the scaled down length scales for various regions of the MS.

Using these scaled down estimates one can try to identify the correspondence between body parts of human body and parts of MS.

Region	d	R
DNA codon	1.0 nm	29 cm
lipid layer cell membrane	2.5-5.0 nm	.73-1.45 m
tubulin	10.0 nm	2.9 m
cell nucleus	1.0 μm	290 m
cell	2.5-25.0 μm	.73-7.3 km
neuron	2.5-100.0 μm	.73-29.2 km

Table 9.3: The scaled up size scales $R = .29 \times 10^9 d = y \times 29$ cm for basic biomolecules, cells, and neurons with size scale $d = y$ nm

1. Pineal gland has radius 3.7 mm which is not far from the size scales 3.5 cm assigned to Earth.

2. Most scales correspond to the scales of brain nuclei which have diameter of 5 cm. Apart from pineal gland these structures of MS are expected to appear as pairs associated with Northern and Souther magnetic lobes.

3. Night-time magnetopause would correspond to a structure with radius .76 m and could correspond to the entire body. Plasma sheet corresponds to size scales in the range $3.6 - 21.5$ cm, perhaps the upper limit corresponds to brain size scale.

One can also ask whether the length scales of DNA and proteins, cell membrane thickness, size scale of cell nucleus, and the range of size scales for cells and neurons could have counterparts at the level of MS and whether one might identify possible candidates for the counterparts for these structures.

Given the size scale d of the molecular or cellular structure the scaled up system should have size scale $R = .29 \times 10^9 d$. System with size 1 nm - roughly the size scale of the DNA codon - corresponds to a system with a size scale 29 cm not far from the size of the brain hemisphere. DNA letter with size scale .33 nm corresponds to scale 9-7 cm. Could the interpretation of the counterpart of the DNA codon as brain hemisphere make sense? Could the brain consisting of three parts be seen as a counterpart of the genetic codon with 3 letters?

The assignment of genetic codon with the brain does not seem to make sense but here an old idea about a hierarchy of codes is suggestive. Ordinary genetic code would correspond to Mersenne prime $M_7 = 2^7 - 1$ and have 2^6 codons. Memetic code assignable to Mersenne prime $M_{M_7} = M_{127} = 2^{127} - 1$ would have 2^{126} codons representable also as sequences of 21 ordinary genetic codons. One could say that one has an abstraction hierarchy in which genetic code corresponds to 64 statements and memetic codons to statements about these statements.

Individual brains do not certainly give rise to analogs of DNA sequences. Here however the notion of magnetic body (MB) providing an abstracted representation of the brain and the biological body is suggestive. The images of neurons at MB near to each other at MB need not be near to each other at the brain level: it is enough that they are functionally similar. This would realize the analog of RAM.

Pietch [**?**] found that the shuffling of the neurons of the salamander brain does not lead to the loss of its functionality. This supports the view about the brain as an analog ofRAM. In an analogous way human and perhaps also other than human brains could serve as analogs for the codons of memetic code mapped to the MB to form linear or even higher-dimensional analogs of the genome. Cultural evolution could mean the emergence of the memetic code.

One can also consider other size scales. **Table 9.3** summarizes the scaled up size scales for basic biomolecules, cells, and neurons.

From the table one finds that the lipids of the lipid layers of cell membrane still correspond to human size scales. This inspires the crazy idea that perhaps humans and possibly other higher animals correspond at the level of MB to analogs of lipids for cell membrane like structures. Larger structures - such as cell and neuron - could correspond to social structures reponsible for collective consciousness generated in the cultural evolution.

9.4 The model for h_{eff} preserving communications based on variable value of β_0

Nottale's gravitational Planck constant $\hbar_{gr} = GMm/v_0$ contains the velocity parameter v_0 as the only parameter. In the perturbative expansion of the scattering amplitudes $\beta_0 = v_0/c$ appears in the role of fine structure constant.

There is however a problem.

1. The model for the effects of ELF radiation on vertebrate brain inspired by a generalization of Nottale's hypothesis by replacing the total mass M in the case of Earth by $M_D \simeq 10^{-4}M_E$ suggests that in this case the dark particles involved couple only to a part of mass identifiable as dark mass M_D.

2. Since only GM appears in the basic formulas, the alternative option is that the value of G is reduced to G_D. This conforms with the fact that in the TGD framework CP_2 length is the fundamental parameter G is a prediction of the theory and therefore can vary.

3. A further option is that the parameter $\beta_0 = v_0/c \leq 1$ is variable and equals to $\beta_0 = 1$ or to a value not much smaller than 1, say $\beta_0 = 1/2$.

These three options are discussed in [L83]. The cautious conclusion is that the third option is the most plausible one. In the sequel I will develop a model for the communications between dark matter phases with $h_{eff} = nh_0$ satisfying $h_{eff} = h_{gr}$ based on the third option. One can consider two options for the communications depending on whether the value of h_{eff} changes as (for instance) in the communications between dark and ordinary matter or whether it is preserved.

1. If the value of h_{eff} can change, energy conservation for $E = h_{eff}f$ allows energy resonance whereas the frequency changes. The simplest option is that the dark photon transforms to say ordinary photon with the same amplitude

2. If the value h_{eff} is preserved, one has both energy and frequency resonance. In the case of cyclotron radiation, the simultaneous occurrence of energy and frequency resonances poses strong conditions on the values of the magnetic fields, the values of charged particle masses, and the parameter β_0 at the ends of the communication line.

9.4.1 Conditions for frequency - and energy resonance

The condition that the frequency is the same at both ends implies for cyclotron frequencies $f_c = ZeB/2\pi m$ the condition

$$\frac{Z_1B_1}{m_1} = \frac{Z_2B_2}{m_2} \quad . \tag{9.4.1}$$

For $h_{eff} = h_{gr}$ the condition that the cyclotron energy $E_c = GMZeB/v_0$ at both ends is same implies

$$\frac{Z_1B_1}{v_{0,1}} = \frac{Z_2B_2}{v_{0,2}} \quad . \tag{9.4.2}$$

Together these conditions give

$$\frac{m_1}{m_2} = \frac{Z_1B_1}{Z_2B_2} = \frac{\beta_{0,1}}{\beta_{0,2}} \quad . \tag{9.4.3}$$

For instance, if the two particles are proton and electron, one obtains

$$\frac{\beta_{0,1}}{\beta_{0,2}} \simeq \frac{m_e}{m_p} \quad .$$

This ratio is is consistent with the values $\beta_{0,2} = 1$ and $\beta_{0,1} = 2^{-11}$ in the accuracy considered. Is this a mere accident?

9.4.2 Resonance conditions for communications from the Earth's surface to the magnetosphere?

The simplest option is that the interacting particles have the same values of mass and β_0 and magnetic fields are identical. This is achieved if the flux tubes have constant thickness. Whether this is the case is not clear.

However, the idea that the flux tube picture about magnetic fields is locally consistent with the Maxwellian view inspires the question whether also the magnetic field strength at the flux tubes of B_{end} behaves like $B_{end} \propto 1/r^3$ as B_E in dipole approximation behaves.

B_{end} is by flux conservation proportional to $1/S$, where S is the area of the flux tube. sOne would have $S \propto r^3$. The constancy of B_{end}/m would suggest $m \propto 1/r^3$. If the charged particles are ions characterized by the A/Z ratio.

This would suggest that the regions of tubes/sheets in frequency resonance are at distances

$$\frac{r}{r_0} = (\frac{Z}{Z_0})^{-1/3}(\frac{A_0}{A})^{-1/3}$$

for ions Z_0, A_0 at the surface of the Earth. The heaviest ions would be nearest to the surface of Earth. Energy resonance condition

$$B_{end}(r)/\beta_{0,2} = B_{end}(R_E)/v_{0,1}$$

would give the additional condition

$$\frac{\beta_{0,2}}{\beta_{0,1}} = (\frac{R_E}{r})^3 = \frac{Z}{Z_0} \times \frac{A_0}{A} \quad .$$

β_0 would be quantized and would decrease with the distance.

9.4.3 Magnetosphere as sensory canvas

TGD leads to a model of the "personal" magnetic body (MB) as being associated with the Earth's MS. Different regions of the body and brain would be mapped to regions of the MS, which would give rise to sensory representations at the personal MB [K57, K55]. Personal MB, which would have size scale of at least of the Earth's MS, would also control biological body.

1. An interesting finding relates to the values of the magnetic field $B_{end} \simeq 2B_E/5$ (perhaps identifiable as the monopole flux part of B_E) and the value of $B \sim 10$ nT in the magnetotail at the night-side of the Earth.

   One has $B/B_{end} \sim 2^{-11}$ so that for dark proton-dark electron communications between the Earth's surface and this region of outer MS the resonance conditions would be satisfied for $\beta_0 = x$ and $\beta_0 = 2^{-11}x$, where $x < 1$ not far from unity.

2. Could the parameter β_0 characterize particles and act as a tunable control parameter allowing to achieve energy resonance? Also the values of B are tunable by changing the thickness of the flux tubes as a kind of motor action of MB.

This idea can be applied to the h_{eff} preserving communications between biological body and the MS of the Earth.

1. The quantum coherence condition suggests that the communications are optimal when the wavelength of dark photon is larger than the distance considered: $\lambda > r$ or equivalently the frequency satisfies $f \leq c/r$ (one has $c = 1$ in the units used). If the structure of the MS has distances from the Earth's surface below r_{max} then the frequencies $f \leq 1/r_{max}$ are optimal.

2. Given the distance r_{max} and assuming $B = B_{end}$ at the surface of Earth, one obtains for the cyclotron frequencies the condition

$$f_c = \frac{ZeB_{end}}{2\pi m} \leq \frac{1}{r_{max}} \quad .$$

For instance, EEG frequency 10 Hz corresponds to 3×10^7 m. The cyclotron frequency of DNA sequence does not depend on its length and composition since DNA has constant charge per unit length. One has $f_c \simeq 1$ Hz so that the corresponding distance is $r = 3 \times 10^8$ m, that is $r = 46.9 R_E$.

Remark: B_{end} probably has a spectrum. Music experiences relies on frequency scale and if the audible frequencies correspond to cyclotron frequencies then eB_{end}/m is variable. This suggests that the spectrum of B_{end} covers at least the range of the audible frequencies spanning roughly 10 octaves [K78].

9.5 Further observations making bells ringing

There are direct observations suggesting that magnetosphere at the level of MB could be a quantum coherent system.

9.5.1 Magnetosphere as self-organizing system

ZEO is now in a central role in the understanding of self-organization [L62]. The new view about time predicts that time reversal occurs in ordinary ("big"") state function reductions (BSFRs) occurring for dark matter at MB whose quantum coherence controls ordinary matter. This has several implications.

1. Dissipative processes occurring in reversed time direction looks like self-organization in the standard time direction. The dissipation of the time reversed system looks like extraction of energy from the environment - an active gain of metabolic energy.

2. Quantum criticality has a description in terms of quantum fluctuations with $h_{eff} > h$ and homeostasis can be understood as self-organized quantum criticality. Dissipation makes possible for the system to stay near criticality contrary to what criticality means by definition.

3. A further implication is that BSFRs look in all scales for an observer with standard time direction like time averages of classical deterministic time evolutions leading to the final 3-D state of BSFR and associated with the final zero energy state. Hence the Universe looks classical in ZEO and the question about the scale in which quantum behavior transforms to classical becomes obsolete. The findings of Minev *et al* [L57] support this picture [L57].

The view that MS is a self-organizing system is supported by the observations accumulated about the magnetic self-organization of the solar system during the last decades reviewed in [**?**]. According to this report we are living a period of transition basically due to a penetration of highly charged material from the interstellar space into the interplanetary space from an interstellar plasma structure containing various kinds of magnetic structures.

This energy feed is inducing various kinds of processes affecting not only the atmo-, iono-, and MSs of Earth but also solar and other planetary MSs. Also interplanetary transmitting properties are affected. The Schumacher-Levy comet, which for few years ago collided with Jupiter and among other things a induced plasmoid train and had dramatic effects on Jupiter's MS, is referred to as a "Comet" SL-9 in [**?**]. I am not sure whether "Comet" was meant to suggest that SL-9 was actually a plasma magnetic structure from the interstellar space. There is also evidence that we are moving to a similar temperature instability that occurred about 10.000 years ago and which might have initiated the development of the bicameral society in turn leading to the modern society much later.

This process could be also seen as a re-self-organization and evolution of consciousness in solar length scale as a reaction to the encounter of heliospheric and interstellar magnetic intelligences. The penetration of interstellar plasmoid like structures to the interplanetary space through the solar magneto-pause could be interpreted as a failure of the magneto-immune system of the helio- MS. The interaction of the planetary MSs with these intelligent (benevolent?) plasmoid like structures would in turn induce the re-self-organization. Needless to say, the interaction of the two intelligences might have far-reaching consequences for the evolution of ordinary life.

9.5.2 Connection with the Comorosan effect

Comorosan effect means that the irradiation of living manner by visible light over a period which is a multiple of $\tau_C = 5$ seconds implies enhanced catalytic activity [I77, I18]. According to private communication, this effect is not restricted to living or even organic matter. TGD explains the effect [K114] but the deeper explanation of the time scale of $\tau_C = 5$ seconds has remained a longstanding challenge.

The 5 second time scale associated with Comorosan effect is the spin flip time scale associated with proton's $\Delta n = 1$ cyclotron transition in the field of $B_{end} = 13.32$ nT (which could correspond to the value of $B_E = 5B_{end}/2 = 33.3$ nT in magnetic lobes). τ_C is also associated with proton's $\Delta n = 3$ cyclotron transition and the electronic cyclotron spin flip in the field of $B_{end} = 2/5B_E = 11.2$ nT (plasma sheet). Lungs contain magnetic particles giving rise to ~ 10 nT magnetic field and thus for $B_{end} = 2B_E/5$ to $n = 3$ protonic cyclotron transitions and electronic cyclotron spin flips in 5.5 second scale, which is very near to τ_C. Perhaps the Comorosan effect is used by the outer MS to affect the behavior of living matter and lungs are involved with this process.

9.5.3 Plasma sheet as a "microchip"

Plasma sheet should be a seat for magnetospheric sensory representations in theta and delta bands and among other things provide a model of magnetospheric self. If the plasma sheet has this kind of role, it should manifest itself in its properties. The plasma sheet should be self-organizing, complex structure rather than a system near thermal equilibrium. In the TGD framework, the plasma sheet could also perform bio-control.

There is a fascinating finding about the "memory chip" character of the organization of the ionic velocity distribution in the plasma sheet [F7]. The belief was that the distribution is a Maxwellian thermal distribution but a complex organization of the number of ions as a function of speed and direction relative to the direction of the local magnetic field has been detected [F7]. By coloring the bins representing small volumes of the velocity space, one finds that 3-dimensional features like "eyes" and "wings" appear! The proposed interpretation is that these features code for the history of ionic currents.

One cannot exclude the possibility that these ionic currents could reflect even our sensory experiences. The prediction is that also other transition regions (in particular magneto-pause) should exhibit similar complex self-organization patterns. The simplest possibility is that the velocity patterns of ordinary electrons reflect the underlying pattern of dark matter at the dark magnetic flux tubes forming perhaps some kind of sensory representations.

9.6 Pollack effect, lightnings and ball lightnings

Ball lightning (see this) is a phenomenon challenging the standard physics. Years ago I wrote about ball lightning and identifying it as a plasmoid, a kind of a primitive life form analogous to a cell. When I learned from the experimental and theoretical work done during this millennium and decided to sharpen my views.

The analogs of ball lighting can be produced in laboratories in strong electric fields using an electric discharge from carbon electron to silicon wafer [D7]. Pure silicon is very rare in nature and appears in the forms of Si oxides, silicates, in particular SiO_2 (see this). Quartz crystals and glass consist of silicon dioxide. In the experiment involving a silicon wafer the globules are divided into two groups: those having sizes in the range .2-.8 mm (high voltages) and .8-1.4 mm (low voltages). The sizes of ball lightning vary from a few millimeters to about 100 cm.

In DC voltage, the wafer decomposes to globules of various sizes. They can last as long as 6-8 second unlike sparks. The proposed explanation is that the globles are evaporated Si. Larger globules have at their surface silicate oxide assumed to be formed in the interaction with air. Larger balls have tube-like extrusions and smaller balls at their surface. They can also rotate and bounce: the energy should come from their decay as an exogenic process. There is evidence for the self-propulsion which brings in mind the motion of bacteria using cilia [D12].

Leo Vuyk has an article about these ball lightning-like objects containing a large number of illustrations (see this).

The theoretical proposal is that ball lightning [D14] (see this) is formed as the lightning strikes on the soil and SiO_2 crystals evaporate and transform to Si and Oxygen. There is support for this from direct observations of the spectrum of ball lightning containing spectral lines assignable to the elements in the soil. The spectra associated with ordinary lightning do not contain similar lines. How the chemical reaction producing Si and O_2 ions from SiO_2 ions could take place is far from clear. A lot of energy is needed for this process to occur. Where does this energy come from?

There is also the so-called microwave theory of ball lightning. Microwave wavelengths vary in the range of 1 mm-30 cm as also the sizes of ball lightning. The ball lightning would correspond to microwave cavities with a dynamical size and shape.

In the sequel a TGD inspired model for the ball lightning-like structures in silicon and for the real ball lightnings is developed relying on the TGD view of space-time predicting fractality and inspiring the hypothesis that biosphere could be regarded as a system analogous to neuronal membrane and that lightnings could be analogous to nerve pulses, the identification of dark matter as phases with non-standard value of Planck constant allowing quantum coherence in arbitrarily long scales, the TGD view of quantum gravitation and its role in quantum biology [L91, L87], and the TGD inspired model of nerve pulse [L117].

9.6.1 TGD view of lightnings

The background for the TGD based model of lightnings and ball lightnings is provided by the TGD view of magnetosphere [K57, K55] [L76] that I have developed during the last decades. The magnetic bodies (MBs) of living systems and even the MB of the biosphere would be controlling agents. These MBs are predicted to have a hierarchical onion-like structure [L109, L110] (monopole flux tubes inside monopole flux tubes). They would carry dark matter as phases of the ordinary matter labelled by the value of effective Planck constant having a number theoretic interpretation. EEEG and its possibly existing scaled variants would make possible the communications to and control by these MBs.

The TGD based view of ball lightning relies on the fractality of the TGD Universe suggesting fractality also at the level of the biosphere. This inspires the notion of the biosphere as an analog of the cell membrane. The TGD view of nerve pulse [K79] and its up-to-date version [L117] inspire the idea that lightning is a scaled up variant of nerve pulse.

Biosphere as analog of neuron

The fractality of the TGD Universe inspires the idea that the Earth ground-atmosphere pair as an analog of neuronal interior-exterior membrane. The background for this discusses is formed by the TGD view of magnetosphere [K57, K55] [L76]. The magnetic bodies (MBs) of living systems and even the MB of biosphere would be controlling agents. Tbese MBs would have a hierarchical onion-like structure [L109, L110].

1. The Earth ground-atmosphere pair is analogous to the cell interior-cell exterior pair. The surface of the Earth is negatively charged and analogous to the cell interior. This negative charge creates an electric field of strength 100-300 V/m (see this). The height h for the clouds varies in the range .5-16 km. For a cloud at height of 10 km this corresponds to an electrostatic energy $.1 - .3$ MeV and for h=16 km one has .48 MeV. In the case of electrons with rest mass of .5 MeV, these energies are relativistic and could relate to the observed relativistic energies associated with the lightning.

2. The thunder cloud (see) has a positive charge near the top of the cloud and negative charge in the middle to lower part of the thunder cloud. At bottom there is a small positive charge known to be important. The negative charge of the cloud repels the negative charge at ground so that ground becomes positively charged below the cloud. Does this induce a local depolarization of the ground-cloud system as the analog of cell membrane?

   This raises an objection against the idea that dark protons are at gravitational monopole flux tubes and that their energies are of the order of the gravitational binding energy in the gravitational field of Earth of order .5 eV. If dark protons experience the Coulombic force of Earth, their Coulomb energies are in the range .8-2.4 MeV below the ionosphere at height

h_I = 80 km, which defines the minimum height of the lower boundary of the ionosphere. The problem disappears since the dark protons at monopole flux tubes are at much larger heights, where the electric field of the Earth vanishes. However, the dark matter at parts of the MB at heights smaller than h_I the electric energy dominates and their role in biology should be very different.

3. Neuronal membrane is hyperpolarized and the nerve pulse is initiated when depolarization takes the membrane potential below a critical value. Could lightning be seen as an analog of nerve pulse induced when cloud-ground depolarization takes place? Thunder storm would be analogous to a conduction of a nerve pulse pattern.

TGD view of nerve pulse

The TGD based model of nerve pulse [L117] relies on the Pollack effect inducing a charge separation between cell interior/exterior and its MB.

1. Pollack effect [I48, L16, I82, I66] occurs in water in the presence of a gel phase. Also energy feed is required and in standard Pollack effect solar radiation provides it. The Pollack effect generates what Pollack calls the fourth phase of water. It has the effective stoichiometry $H_1.5O$ and every fourth proton of water has gone somewhere. In the TGD based model they would transform to dark protons at the gravitational MB of the Earth.

2. Pollack effect inside the cell would generate negatively charged EZs making the cell negatively charged. The dark protons would reside at the gravitational MB of Earth having astrophysical size and are therefore effectively outside the system. The negative charge of EZs induces positive polarization charges in the cell exterior. The properties fo EZ suggest that second law holds in a reversed time direction and large scale quantum coherence zero energy ontology (ZEO) [K115], predicting that the arrow of time changes in the ordinary state function reductions, can explain this.

3. In the nerve pulse generation, the reverse Pollack effect would occur and neutralize the negative charge of the cell interior locally [L117]. This would induce a local depolarization.

   The reverse Pollack energy generates dark photons and is received by the water in the neuron exterior. This would induce Pollack effect in the cell exterior and generate a negative charge as EZ outside the cell so that membrane potential would change its sign temporarily. An effective charge transfer induced by the Pollack effect and its reversal occurs: a kind of quantum flip-flop is in question. The possibly Ohmic ionic currents associated with the nerve pulse are generated as a consequence but could be seen as a side effect rather than a cause of the nerve pulse.

4. In zero energy ontology (ZEO), nerve pulse corresponds to two pairs of BSFRs ("big" state function reductions) corresponding the reduction of membrane potential to its negative and the reversal of this process [L117]. Each pair involves a temporary change of arrow of time: this would conform with the formation of EZs.

Lightning as an analog of nerve pulse?

Could lightning and nerve pulse be generated by the same mechanism?

1. The fractality of the TGD Universe inspires the proposal that the Earth's biosphere and its MB [K57, K55] [L76, L109, L110] are analogous to a cell membrane or even neuronal membrane or possibly a collection of basic units analogous to those of neuronal membranes. In the lightning strike, a charge separation between ground and its MB would transform to a charge separation between cloud and its MB. Lightning would be induced by the depolarization just as in the case of neuronal membrane.

   The assumption distinguishing sharply between TGD and standard physics is that the primary charge separation does not occur between cell interior and exterior but between interior/exterior and its MB.

2. In the initial, rather stationary situation, the Pollack effect at the ground has generated EZs and made the Earth surface negatively charged. The electric field of the Earth gives rise to the analog of the resting potential of neutrons as the voltage between ground and (say) the cloud. Negatively charged EZs at the ground induce the small positive charge (known to be important) at the bottom of the cloud by polarization.

3. The reverse Pollack effect would occur at the ground and partially neutralize the negative charge of the ground locally and induce a local depolarization. The energy transfer by dark photons to the cloud would induce Pollack effect in the cloud generating negatively charged EZs and lead to a local depolarization in the cloud, which effectively looks like a transfer of negative charge to ground. This would change the sign of the electric field locally or at least reduce its strength.

   A moving thunderstorm accompanied by lightning strikes would be analogous to the nerve pulse conduction. The ion currents between cloud and ground are analogs of various ionic fluxes during the nerve pulse. Both oscillating Josephson currents along the gravitational monopole flux tubes and Ohmic currents are possible.

   Also nerve pulse conduction would be seen as a temporal sequence of local lightning at discrete positions at discrete times. This conforms with the TGD based model for nerve pulse in terms of propagating Sine-Gordon solitons associated with a sequence of effective mathematical pendulums [K79] [L117].

It would be interesting to relate the parameters of nerve pulse conduction (say conduction velocity) to the parameters of the propagation of thunderstorms. Also the parameters corresponding to those appearing in the TGD based model of nerve pulse in terms of Josephson junctions and dark Josephson currents would be highly interesting. The dream would be a quantum model for a thunderstorm.

Biosphere as a Josephson junction

What could the identification of the biosphere as a Josephson junction or collection of them could mean? Consider first the neuronal membrane [L117].

1. In the case of the neuronal membrane, one has a collection of Josephson junctions defined by monopole flux tubes assignable to membrane proteins believed to act as channels and pumps. This collection can be idealized with a continuous Josephson junction with the phase difference associated with supra phases at the two sides obeying Sine-Gordon equation [K79].

2. The Coulomb energy $E_J = ZeV$ allows an interpretation as a Josephson energy of charge Z (say Cooper pair with $Z = 2$). For $\hbar_{eff} = \hbar_{gr}GMm/\beta_0$ the corresponding frequency is $f_J = ZeV/h_{eff}$. This frequency depends on the mass m of dark charge assignable to gravitational monopole flux tubes. M could correspond to some large mass, such as the mass of Earth, Sun, or Moon.

3. The generalized Josephson energy assignable to the junction is assumed to be sum of E_J and of the difference of cyclotron energies assignable to the flux tubes arriving to the cell membrane from the cell interior and exterior. The difference of cyclotron energies would give the dominating contribution to the generalized Josephson energy and would be equal to the cyclotron energy at the gravitational magnetic body. For this option, ordinary Josephson energy would code membrane potential oscillations and even nerve pulse to a small modulation of the generalized Josephson energy and - frequency.

4. At the gravitational MB, assumed to be an onion-like structure consisting of nearly spherical layers [L109, L110], cyclotron resonance must occur in the receival of the dark Josephson radiation. The condition for this is that the dark cyclotron energy $E_c = \hbar_{gr}ZeB/m = GMZeB/\beta_0$ (by Equivalence Principle, there is no dependence on m) is equal to the generalized Josephson energy.

5. If there is no cyclotron contribution to the generalized Josephson energy, it reduces to the ordinary Josephson energy $E_J = ZeV$ and the resonance condition implies that M must correspond to the mass $M_M \simeq 1.02M_E$ of the Moon! [L117].

   This does not occur if the cyclotron contribution dominates and the cyclotron resonance condition can be satisfied for M_E and the variation of membrane potential is coded to a sequence of resonances analogous to a sequence of nerve pulses. Nerve pulse patterns could indeed be preceded as a reaction of the MBs of sensory receptors to dark Josephson radiation.

Could this picture of the cell membrane as a Josephson junction generalize to the recent situation?

1. Suppose that also in the recent case the generalized Josephson energy involves the difference of dark cyclotron energies besides the ordinary Josephson energy and that it dominates. Suppose that one replaces the mass M, say the mass of Earth, appearing in $\hbar_{gr}$ by the mass M_S of say Sun. Assume that the Earth's mass appears in $\hbar_{gr}$ for neurons.

2. If the membrane potential scales as $V \to (M/M_E)V$, the resonance conditions remain true since they do not depend on M at all. This would extend the Equivalence Principle so that it would apply to both M and m. Neuronal membranes could couple to the gravitational MBs of both Sun, Earth and even Moon.

   The scaling factor of V would be $M_S/M_E \simeq 3 \times 10^5$ and in the case of membrane potential would give $V = .05$ eV $\to V = 15$ keV. The height h of the thunder cloud varies in the range $[.5, 16]$ km. The ratio h_{max}/h_{min} of the maximum and minimum heights is $h_{max}/h_{min} = 32$, which is a power or 2 and brings in mind p-adic length cdale hypothesis.

   Note that the scaling down by M_{Moon}/M_E would give $V = .5$ meV, which corresponds to the scale of miniature membrane potentials modulating neuronal membrane potential.

3. The ratio of the maximum and minimum electric fields strengths is roughly $E_{max}/E_{min} = 3$ and considerably smaller that the ratio $h_{max}/h_{min} = 32$ so that the correlation between E_{max} and h is weak. In the absence of a correlation between E and h, and at the height of 10 km, the range would be $[.1, .3]$ MeV. A cloud at height of $h = 16$ km, which is also possible, corresponds to an electrostatic energy in the range $[3.2, 9.6]$ MeV.

   As noticed, this model can explain the relativistic electron energies assigned with the lightning. The electrons would propagate along monopole flux tubes with a large value of h_{eff} and dissipation would be absent.

There are many interesting questions to be answered.

1. Both the cell membrane and ionosphere can be seen as a capacitor like system or battery. The lower boundary of the ionosphere is at the height h_I between 80-600 km. Ionosphere contains a layer of electrons and can seen as an analog of negatively charged conductor plate of a capacitor formed by the positively charged Earth surface and ionosphere. Radio waves are reflected back from the ionosphere. Schumann resonances are associated with it.

2. Neuronal membrane corresponds to the p-adic length scale L(151)= 10 nm and its lipid membranes to L(149). L(151) corresponds to Gaussian Mersenne. Can one assign a Gaussian Mersenne also to the ionosphere?

   After the Gaussian prime $G(167)$ defining p-adic length scale of 2.5 μ m, size of cell, the next Gaussian Mersenne is $G(239)$ and corresponds to $L(239) \simeq$ 160 km and has $G(241)$ as Gaussian twin prime. 160 km is roughly the height of the lower boundary of the F region (ionosphere decomposes to D,E, and F regions and the electron density is highest in the F region).

   The scale of 80 km is one half of $G(239)$ brings in mind lipid layers of the cell membrane to which one assigns capacitor plates. Could one think that the crust of Earth with thickness between 4.7 and 69 km defines the analog of the second capacitor plate.

3. In the cell membrane, the transversal scale of channels and pumps is about 10 nm and corresponds to the p-adic length scale $L(151)$ and the same as cell membrane thickness. What could be the counterparts of the membrane proteins assumed to be accompanied by Josephson junctions?

   Thunder storms (see this) are known to decompose to cells. Either these cells or thunder clouds could correspond to the basic units of cell membrane with the size scale $L(151)$. In the TGD based quantum view of hydrodynamics [L81], these structures would be hydrodynamical vortices (such as tornadoes) accompanied by monopole flux tube structures.

   Thunder clouds are at heights varying in the range [.5,10] km and the height and diameter of clouds is 10-20 km. Could this scale or the size scale of the cell correspond to the size scale of the basic unit of cell membrane and therefore to $L(239)$. This scale is however several orders of magnitude smaller than $L(239)$.

9.6.2 Ball lightning in the TGD framework

Could one understand the generation of ball lightning in this framework?

1. Suppose that in the normal situation the Pollack effect [I48, L16, I82, I66] for the water at the soil has somehow generated EZs and SiO_2 ions from Si and water of the soil or atmospheric oxygen. This would explain the negative charge of the ground. The Pollack effect would not require energy feed now since the binding energy liberated in the formation of SiO_2 crystals would take care of energy conservation. A situation in which part of water corresponds to $H_{1.5}O$ ions would be energetically favored.

   Note that this mechanism could be very general and make possible a quantum gravitational control of molecular transitions with binding energies in eV range. This would make it possible to establish plasma-like state typical for electrolytes by the Pollack effect and also induce a temporary decay of the biomolecules by the reverse Pollack effect providing the energy making it possible to overcome the energy barrier. This would be essential for biocatalysis.

2. In the reverse Pollack effect associated with the lightning strike, dark protons from MB would transform ordinary protons and return to the ground. The liberated energy would make possible the decay of SiO_2 molecules to Si and O_2. Ordered water would transform to ordinary water getting its oxygen ions from SiO_2.

3. This situation is not energetically favored. The Pollack effect would take place and lead to the original situation in a time scale of a few seconds. The slow time scale could relate to the large value of $\hbar_{gr}$. The liberated gravitational binding energy in the Earth's gravitational field for a single dark proton is below .5 eV, which corresponds to the nominal value of metabolic energy currency [L91, L87].

   Note that the counterpart of the membrane potential energy $E = eV$ is in the recent case in the range .1-30 MeV and much higher than the scale of the molecular binding energies. These energies are consistent with the finding that gamma rays accompany lightning strikes.

Connection with crop circles, UFOs, and glass balls in the Moon

A connection with crop circles is highly suggestive. I have discussed crop circles from the TGD point of view in [K35, K36] in a rather speculative spirit but starting from empirical facts published by professional biologists. There are reports that the crop circle formation occurs in presence of light balls analogous to ball lightning. The formation of crop circles can be understood in terms of the interaction of microwaves with crop stems causing effects similar to those taking place as one puts a tomato in a microwave oven. The size scale range for ball lightning conforms with the wavelength range for microwaves. Therefore the microwave theory seems to be consistent with the model based on the Pollack effect. The light ball would be an analog of the nerve pulse in the scale of the biosphere.

Meteorite iron is found at crop circles: they could arrive from the gravitational MB along gravitational flux tubes. Also small glass balls, encountered also on the Moon, are reported. They could emerge in the transformation of Si and O_2 to SiO_2 as the Pollack effect takes place.

What is fascinating is that crop circles look like intentional constructs expressing discrete geometric symmetries. Could the plasma balls be intelligent conscious entities, a new kind of life form and could they represent the primordial life forms, kind of proto cells? This kind of plasma balls are also reported in UFO encounters. Systematic observations of the plasma balls are performed in Hessdalen and the plasma balls are reported to behave like intelligent and intentional entities.

The gravitational MB of these entities would correspond to that of the Sun. Could this mean that their theoretical IQ, defined by the gravitational Planck constant of the Sun, is dramatically higher than ours? Probably this is not the case: the gravitational Compton frequency for the Sun is around 50 Hz. This is the cyclotron frequency of Lithium for $B_{end} = .2$ Gauss. It is known that too low Li depletion in the soil tends to induce depression and suicidal behavior. 50 Hz corresponds to EEG frequency so that life forms with EEG would interact with the gravitational MB of the Sun.

Are we silicon based life forms?

Computationalists tend to think that silicon based life will emerge in future. However, if the above considerations make sense, Si, chemically similar to Carbon and appearing as quartz in soil, could play a central role in life already now! Maybe the people claiming that quartz have very special effects on the state of consciousness, are right. In fact, I have had an opportunity to experience these effects myself.

Intriguingly, molten silica shows several characteristics observed in liquid water (see this) and the amorphous glass phase of silica resembles liquid in many aspects.

Interestingly, silicon di-oxide is used in MOSFETs. In [L104, L103], I have considered a model for how ordinary computers could become conscious entities. This requires the failure of statistical determinism in long enough time scales. The proposed condition would be that the gravitational Compton frequency 67 GHz for Earth (microwave wavelength), which corresponds to a wavelength of .5 cm for Earth (the size scale of a snowflake), is longer than the clock frequency. This condition is not quite true for recent computers.

If ordinary computers can be conscious, the properties of MOSFETs must be in a crucial role. Is this possible?

1. The SiO_2 in MOSFETs could have a glassy, spin glass-like structure to give them high representative capacity and there is some evidence for this. The transistors should also define Josephson junctions. The alternative, more promising option, discussed in [L103], is that the conscious computer is based on the representation of bits in terms of Josephson junctions.

2. MOS is obtained by growing a layer of Si on top of SiO_2. However, the idea about the local transformation of SiO_2 to Si and O_2 with Si in vapour phase by an analog of the Pollack effect does not look plausible since protons are not available now.

   Electrons should be transformed to dark electrons at the gravitational MB of Earth and the formation of SiO_2 would make possible energy conservation. The transformation of electrons back to ordinary electrons liberates energy and should induce the decay of SiO_2. The needed energy is few eVs. However, the gravitational binding energy for electrons in the field of Earth has an upper bound of order .25 meV. Note that the melting temperature of SiO_2 corresponds to the energy .134 eV. It seems that the only possibility that one can imagine is provided by dark variants of quantum coherent many-electron states.

Chapter 10

About long range electromagnetic quantum coherence in TGD Universe

10.1 Introduction

The focus of TGD inspired quantum biology has been hitherto in long range quantum gravitational coherence characterized by quantum gravitational Planck constant $\hbar_{gr} = GMm/\beta_0$ introduced by Nottale [E2]. The notion of gravitational Planck constant however generalizes also to other classical fields, in particular electric fields.

1. The generalization of Nottale's formula to electromagnetic interactions reads as

$$\hbar_{em} = \frac{Z_1 Z_2 e^2}{\beta_0} \quad ,$$

where $\beta_0 = v_0/c \leq 1$ is velocity parameter and has discrete spectrum. The number theoretically motivated guess is $\beta_0 = 1/n$, $n = 1, 2, ...$ [L43].

2. The phase transition $\hbar \to \hbar_{em}$ occurs when the perturbation series fails to converge: one can say that Nature loves theoreticians [L102, L118]. The criterion is

$$Z_1 Z_2 \alpha \geq k \quad ,$$

where k is expected to be near unity. Just as in the case of gravitation, the perturbation series for h_{em} is in powers of

$$\frac{Z_1 Z_2 e^2}{4\pi\hbar_{em}} = \frac{\beta_0}{4\pi} \quad .$$

3. For a charge distribution, the total em charge is given as electric flux $Q = \oint E \cdot dS/4\pi$ in units in which Coulomb potential of a unit charge is $V = e/r$ and one has $E = -\nabla V$. For a charged sphere (say conductor) with radius R one has $E = 4\pi\sigma$, where σ is the density of the surface charge. One has $Q = \sigma 4\pi R^2 = ER^2$. In this case, the criterion for a system consisting of unit charge e and charged sphere becomes

$$r = \frac{eQ}{\hbar} = \frac{eER^2}{\hbar} \geq 1 \quad .$$

It is easy to imagine situations in which $\hbar_{em}$ could be relevant. Nanoscopic, macroscopic and even astrophysical quantum coherence associated with electric fields is possible. What is of special interest is that all objects with gravitational mass must have some electroweak gauge charge, which

is non-vanishing although it can be arbitrarily small so that all pairs formed by astrophysical object and charged particles could be characterized by $\hbar_{em}$ and corresponding electric Compton length.

In the sequel the applications to biology and to the possible interactions of computers and living systems will be discussed. The application of the condition of electric quantum coherence to linear structures such as DNA and neuronal axons yields a condition on the Compton length and thus the mass of the charged particle considered. Miraculously, the condition is satisfied for electrons!

10.2 Biological applications of long range electromagnetic quantum coherence and generalized Pollack effect

In this section the biological applications of the electromagnetic Planck constant and generalized Pollack effect will be discussed.

10.2.1 DNA double strand

DNA is a unique bio-molecule (see for the TGD based model in [L98]) in that it carries constant negative charge per unit length. DNA double strand has negative charge -e per nucleotide so that the codon pair carries charge of 6 units.

1. For the double strand, one has $Z_1 = Z_2 = Z$ and the proposed rough criterion holds for $Z^2 \geq k/\alpha$, giving $Z \geq 12k$ which corresponds to three codons as minimum quantum coherent system with $\hbar_{em}/\hbar \geq 1$. In terms of the number N of codons this gives

$$\frac{\hbar_{em}}{\hbar} = \frac{36N^2\alpha}{\beta_0} \quad .$$

2. For a double DNA strand interacting with a unit charge e, the rough criterion is $2Z \geq k/\alpha$ giving $Z \geq 69k$, which corresponds to 23 codons. This corresponds to DNA length of about 20 nm. Interestingly, memetic codon corresponds to 21 codons. This suggests that k is slightly below $k = 1$.

   For an open DNA double strand during transcription 21 codons corresponds to 6 full turns [L98]. During transcription DNA interacts with the environment and it would be natural that the $\hbar_{em}$ characterizing DNA + electron/proton system becomes relevant during translation. In this case one has

$$\hbar_{em} = \frac{12Ne^2}{\beta_0} \quad .$$

   $\hbar_{eff}$ serves as a measure for algebraic complexity and a kind of universal IQ. This suggests that the electric body of DNA + environment can also control the nearby environment. The MB of the double strand would take the role of the brain with a much larger IQ than DNA + environment.

10.2.2 Biological membranes

The nuclear -, cellular-, and neuronal membranes are in key roles in biology and interesting to see whether the value of the parameter $eQ/\hbar$ for the system formed by a unit charge e and membraned bounded system exceeds $\hbar$.

Just for definiteness, let us assume that the electric voltage over the membrane has a nominal value of $V = .05$ eV and that the thickness d of the neuronal membrane is $d = L(151) = 10$ nm. This gives an electric field of $E = 5$ MV/m. For the ordinary cell membrane, the thickness d is near to $d = L(149) = 5$ nm. Assume that this is also the thickness of a nuclear membrane.

1. Neuronal membrane with thickness about $d = L(151) = 10^{-8}$ m and radius of about $10^{-5} - 10^{-4}$ m corresponds to $E \simeq 5$ MeV/m. For $R = 10^{-5}$ m, one has $r = eQ/\hbar = eER^2 = 6.2 \times 10^2 > 1$ so that the criterion is satisfied. The Compton length of electron is scaled up by a factor $\hbar_{em}/\hbar$ to nanometer scale (DNA scale) for $\beta_0 = 1$. For $R = 10^{-4}$ m, one has $r = 6.2 \times 10^4$. This scales the Compton length of electrons to about $L(151)$ $\beta_0 = 1$.

2. For a cell membrane, with $d = L(151)/2$ and $R = 10^{-5}$ m, one has $eQ/\hbar = 1.24 \times 10^3$. For nuclear membrane with $R = L(163) \sim 2.5$ μm and $d = L(151)/2$ $eQ/\hbar = 3.2 \times 10^2$.

10.2.3 Ionosphere as an analog of neuronal membrane

Electric quantum coherence can be considered also in astrophysical scales. Ionosphere, identified the ionized part of the atmosphere, is of a special interest since it corresponds to the electric field in the Earth scale: see the Feynman lectures. Ionization is caused by solar radiation. Also other planets are believed to possess an ionosphere.

Assuming that the surface of Earth and ionosphere define a system analogous to capacitor plates or cell membrane, the ionosphere must have a net positive charge assignable to positive ions. In [L114] a model for lightning and ball lightning based on the idea that thunderstorms are analogous to nerve pulse patterns for which Pollack effect provides a model [L117], was developed.

The strength of the electric field at the negatively charged surface of Earth E is $E = .1 - .3$ x kV/m, $x \in [.1, .3]$. The presence of biological protrusions such as trees can increase the local value of the electric field of Earth by an order of magnitude. The counterpart of the positively charged plate corresponds to the ionosphere, whose lower boundary is at the height h, which varies in the range [80,600] km. The net positive charge of the ionosphere neutralizes the negative charge of the Earth so that the electric field does not extend to higher heights.

The first for the electric Compton length is obtained by generalizing the notion of gravitational coupling constant to the electric case as $\hbar_{em} = Qe/\beta_0$, where Q is the total charge of the Earth and the value of β_0 could be taken the same as in the gravitational case and $\beta_0 = 1$ for Earth and other planets and and $\beta_0 \simeq 2^{-11}$ for Sun.

The basic question is whether the entire ionosphere acts as a quantum coherent system or whether electric flux tubes possess electric quantum coherence. The intuitive idea is that the quantum coherence scale in the case of the ionosphere regarded as a capacitor-like system should not be longer than the thickness of the ionosphere varying in the range 60-100 km. The radius d of the electric flux tube is a good first guess for the electric Compton length. Lightnings are analogs of nerve pulses and characterized by a scale of 10-20 km and is a good guess for the quantum coherence length.

The electric Compton for a particle with mass m is defined as

$$\begin{aligned} \Lambda_{em}(d) &= \frac{\hbar_{em}}{m} = \frac{Q(d)e}{\beta_0\hbar}\lambda \quad , \\ Q(d) &= \epsilon_0 E \pi d^2 \quad , \end{aligned}$$

where $Q(d) = \epsilon_0 E_E \pi d^2$ is the electric flux associated with the electric flux tube and λ is the Compton length of a charged particle, say electron, electron Cooper pair or proton. The proposal is that it satisfies the consistency condition

$$\Lambda_{em}(d) = d \quad .$$

10.2.4 Generalized Pollack effect as a key mechanism of quantum biology

The role of Pollack effect in hydrodynamics, biochemistry, and biology has become increasingly clear.

1. The presence of water and gel phase and energy feed is essential for the Pollack effect in its basic form [I48, L16, I82, I66]. The Pollack effect explains the large number of anomalies of water [L113]. Pollack effect would play a central role in biology and explain the negative charge of cell and DNA in terms of exclusion zones (EZs).

2. The model for the lightnings and ball lightnings [L114] relies on a generalization of the Pollack effect, which would generate the electric field of Earth. Protons transform to dark protons at the monopole flux tubes inside the ionosphere. This process requires energy since the electrostatic binding energy is reduced in the process. The transformation $Si + O_2 \to SiO_2$ liberates energy and makes possible the Pollack effect for water, which transforms part of protons to dark protons in the ionosphere below it at much higher heights where only gravitational binding energy matters. This generates negatively charged exclusion zones making Earth negatively charged.

   Ball lightning involves the reversal of this process and generates Si vapor droplets having SiO_2 at its boundary. These structures could represent primordial life forms, which I have called plasmoids in the earlier articles, and explain UFOs and similar phenomena.

3. Urey-Miller experiment [**?**] meant a dramatic step of progress on the experimental side, and for a long time it was believed to conform to the vision of Oparin and Haldane. The experiment involved a reducing atmosphere and electric sparks simulating the effect of lightning. In the later experiments 19 of 20 amino-acids were identified. Also nucleosides A, G were produced. Cyanoacetaldehyde together with urea believed to be accumulated to primordial ponds, allowed to generate U and C as was discovered by Miller 40 years after his classical experiment. These impressive results were interpreted as a support for the view about primordial ocean as a "dilute soup" of organic molecules which precipitated out of the atmosphere.

   I have discussed the role of Pollack effect in the explanation of the findings of the Urey-Miller experiment [L67] and the model of ball lightning allows to make the model more detailed.

   The generalized Pollack effect could drive the formation of fundamental biomolecules and the emergence of life. This process would provide the energy needed to drive protons to dark protons at the atmospheric part of the MB of Earth, where it would gradually start to control the emerging bio-matter. The reversal of the Pollack effect would tend to transform dark protons to ordinary protons and its compensation would create more basic biomolecules. Pollack effect could also generate dark photons serving as a communication tool. Only certain bio-molecules could form networks communicating by a mechanism involving dark radiation generated by generalized Josephson junctions and by Pollack effect and received by cyclotron resonance.

   This process could also occur in the underground oceans: what is required are electrically charged membrane bound structures creating a strong enough electric field.

4. Pollack effect and its reversal are essential for the model of nerve pulse [L117] based on flip flop mechanism in which the reverse Pollack effect in the neuronal interior provides dark photons inducing the Pollack effect in the neuronal exterior and reverse the sign of membrane potential during the nerve pulse.

5. Pollack effect plays a key role in the model of the transfer of metabolic energy from the Earth's core [L99] to the underground oceans where a photosynthesizing life would have evolved and bursted to the surface of the Earth in Cambrian explosion accompanied by rather rapid expansion of Earth size by factor 2. In this case the Pollack effect would take place for superionic ice for which oxygen ions form a lattice and protons form a liquid like structure. The earlier model assumed gravitational MB but its replacement with the electric MB does not affect the model appreciably.

   Plasmoids as analogs of ball lightning created by $SiO_2 \to Si{+}O_2$ process could be primitive life forms. Could this process take place at the boundary of the superionic ice?

6. Pollack effect generalizes to other molecules and provides a concrete realization for the general vision that MBs control biochemistry. The ionospheric, electric part of MB could control molecular biochemistry in a few eV range by inducing the formation of molecules and their decay by Pollack effect and its reversal.

Ionization is one of the poorly understood aspects of biochemistry and of electrolysis in particular. MB could control the ionization of molecules at the surface of Earth by using the Pollack effect.

1. The transformation of protons to dark protons below the ionosphere would create dark variants of protonic holes assignable with negatively charged bio-molecules in the sense that the missing proton would be dark and at the magnetic body and its motion would correlate strongly with the motion of the hole at the "biological body" (BB). The flip flop mechanism makes possible a hopping mechanism of conductivity possibly realized for superionic ice proposed to be present above the core of Earth. The hopping of the dark proton to the MB of the neighboring molecule would correspond to the Pollack effect followed by its reverse. This process at the level of MB would force a corresponding process at the level of BB. No currents at the level of MB would be involved and, as in the case of nerve pulse, the basic process would be the charge separation between MB and BB.

2. Negatively charged ions at the right end of the periodic system could in turn be generated by the electrons of EZs created in the Pollack effect so that Pollack effect could explain the ionization of biomatter and of electrolytes.

10.2.5 Can the Moon travellers survive in the TGD Universe?

In the proposed vision, biology would depend strongly on planetary and even solar parameters. Both classical electric, magnetic , and gravitational fields (in the TGD sense) in astrophysical scales and the dark matter at the field bodies are essential for the model. This might not be good news for those who have dreams of life on Mars and Moon.

Moon travellers have however survived. Does the proposed vision survive this fact?

1. Consider first the gravitational MBs of the Earth and Moon. As far as the quantum gravitational model of metabolism is considered, the gravitational MB of the Moon would replace that of Earth. Intriguingly, if the generalized Josephson frequencies, which must be equal to cyclotron frequencies at MB, reduce to the ordinary Josephson frequencies, the Josephson radiation from cell membranes must go to the gravitational MB of the Moon! This condition can be true also more generally and there is a considerable flexibility. Therefore the model for the cell membrane survives.

2. The quantum gravitational model of the metabolic energy currency [L91, L87] relies on the observation that the gravitational binding energy of protons at Earth is rather near to the metabolic energy currency with nominal value $e = .5$ eV. The proposal is that dark proton triplets at the gravitational MB of Earth carry the metabolic energy.

   The distance of the Moon from Earth is $60R_E$ so that the gravitational binding energy in Earths' gravitational field is about $e/60$. The gravitational potential energy for the Moon is related to that for Earth by the scaling factor $(M_M/M_E) \times (R_M/R_E) \simeq .04$. This gives .02 eV for the upper bound of the gravitational potential energy. This is by a factor 1/25 too small. One can of course consider the possibility of replacing protons with ions or atoms with large enough mass. Amusingly, for Si with atomic weight 28 one would obtain standard metabolic energy quantum as maximal gravitational binding energy. This and the fact that there is no deep reason why the electric field of Earth could not take the role of gravitational field, forces us to take a critical attitude concerning the quantum gravitational metabolism.

3. The electric field at the surface of Moon is $E_M = 6$ kV/m and surprisingly strong, stronger than $E_E = .1 - .3$ kV/m. $\hbar_{em}/\hbar$ is scaled by the factor $(E_M/E_E)(R_M/R_E)^2 \simeq 4.2$. Maybe the view about the control of molecular chemistry by MB could survive. The problematic metabolic energy currency could correspond to the Coulomb energy in the electric of Earth below the ionosphere. The electric energies vary in a wide range up to MeV scale for the height $h = 10$ km: the molecular energy scales of course limit the upper boundy to UV energies. If also the gravitational realization of the metabolic energy currency is possible for Earth, Earth would be very special.

4. There is still a problem: Moon's magnetic field B_M is very weak. A possible solution, proposed also in the case of Mars (which has auroras requiring magnetic field), is that the Moon has only the dark part of the magnetic field, which for Earth is the endogenous magnetic field $B_{end} = 2B_E/5 \simeq .2$ Gauss explaining the findings of Blackman and others.

This would be essential for understanding EEG in terms of cyclotron frequencies. Note that the dark part is a monopole magnetic field and needs not currents whereas the ordinary Maxwellian part is generated by currents.

This forces us to challenge the assumption that the measured magnetic field is the sum of its monopole part and Maxwellian part. Since the cyclotron energies for these parts are widely different one could ask whether the requirement that energy eigenstates are in question, prevents the wormhole contacts of charged particles with both the Maxwellian and monopole flux tubes.

10.3 Long scale electromagnetic quantum coherence in non-biological systems

The basic form of the Pollack effect involves water and gel phase so it seems that possible applications of electromagnetic long range quantum coherence must always also include organic matter and water. The effect however generalizes.

10.3.1 About the Biefeld Brown effect

Biefeld Brown effect is one of the effects studied by "free energy" researchers. What happens is that an asymmetry capacitor for which the electrodes are of different size starts to move in the direction of the smaller electrode. The so called emdrive (see `http://tinyurl.com/zkwoehe`), which I have commented in [K89] [L25] could be also based on this effect. There has been a lot of overhyping such as vehicles moving with light-velocity to Mars and the failure of momentum conservation byt the Biefeld Brown effect is real.

The recent experiments carried out by Buhler's team using capacitor-like systems in vacuum chamber to achieve a levitation in the gravitational field of Earth (see this). If this is really the case, new physics is involved.

The original experiments of Brown

Biefeld Brown effect is discussed in [H4, H5, H9] (see also this). The electric fields associated with the capacitors are about 30 kV/dm, which is about 10 percent of the electric field 30 kV/cm causing dielectric breakdown in air. Note that the electric field of Earth is 10-30 V/dm and therefore roughly by a factor 1/1000 weaker.

Brown makes several important statements, including:

1. The acceleration is in the direction of the smaller electrode.
2. The greatest force on the capacitor is created when the small electrode is positive. This could be understood if positive ionic currents are responsible for the effect.
3. The effect occurs in a dielectric medium (air).
4. The effect can be used for vehicle propulsion or as a pump of dielectric fluid.
5. Brown's suggest that the effect involves ionic motion.
6. The detailed physics of the effect is not understood.

Standard physics based models for the effect are discussed in [H9]. The models assume that the cm motion is due to the loss of energy and momentum to the environment and fail if the effect is possible in vacuum. The first model assumes ionic wind between the electrodes and predicts effect, which is 3 orders of magnitude too small. The model based on ionic drift is a rough order of magnitude model and predicts that the effect can have an order of magnitude consistent with the findings. The reason why the ionic wind predicts a smaller effect is that the absence of dissipation tends to reduce the effect since the ions arriving to the opposite electrode induce an opposite recoil.

Interview of Charles Buhler by Tim Ventura

The interview of Charles Buhler by Tim Ventura (see this) gives more details about what has been found in the experiments giving a thrust which is now around one g. Buhler's team has been developing the propellantless propulsion based on asymmetric capacitor-like systems understood in a very general sense, i.e. there are just two electrodes which are asymmetric. The work is completely independent of NASA and has been patented. Consider first the experimental arrangement.

1. Electric field is more intense at the smaller electrode and is believed to make the effect larger. In the experiments Brown the effect was larger when the smaller electrode positively charged.

2. The electrodes are cased which means that there is no leakage of charge between them. The claim is that this prevents all kinds of leakage currents between the electrodes. The system is also enclosed in high vacuum and this allows the use of lower voltages.

Buhler emphasizes that there are profound differences between the situation in the recent experiments and experiments of Biefeld Brown.

1. In standard physics the center of mass of an isolated system must remain at rest. Now the system is in a vacuum chamber and there is no charge leakage between the electrodes and the findings demonstrate that there is a center of mass motion in vacuum. Therefore there should exist a momentum and energy exchange with some unidentified system. Charges and/or radiation should leave the electrode to produce a recoil and recoils not compensate for each other and the asymmetry of the system guarantees this.

2. Mere charge and electric field are enough to generate the thrust and no external energy is needed. This suggests that the electrostatic energy provides the needed energy.

3. There are two types of charges involved. The free charge appearing in conductors and the bound charge appearing in insulators. The interpretation could be in terms of electrons. Bound charge could correspond to valence electrons which do not become conduction electrons but something else. It is reported that at low voltages free charge dominates the effect and at higher voltages bound charge dominates. The interpretation could be in terms of ionization in high enough voltage in which bound charges go somewhere. The bound electrons increase the thrust dramatically. In the latter case an ionization of atoms is required.

What happens to the electrons?

1. Without a transfer of electron momentum to the degrees of freedom of X, the generation of the center of mass momentum is impossible. The electrons transferred to X end up to the opposite electrode or drop back to the original electrode and in this process pump momentum to X. The asymmetry suggests that the pumping from the smaller electrode is more effective.

2. Suppose that the electrons get their energy from the electrostatic energy of the capacitor-like system and the net charge of the system remains zero. This requires that there is a net transfer of negative to the positive electrode. It is easy to see that the accumulation of negative charge to the third party system, call it X, is not possible. Therefore the momentum of electrons must be dissipated or transferred to some internal degrees of freedom of X.

3. One cannot exclude the possibility that some fraction of electrons remain to X for a relatively long time. This would lead to a generation of a net positive charge. The capacitor system would experience a force in the electric field of Earth. If there is a third system involved then the capacitor type system and the third system behaves like an electric dipole in the electric field of Earth. Since the Earth is negatively charged, the force would tend to decrease the thrust. In this case a current is needed to preserve the charges of the electrode.

TGD based model of the effect

1. Basic ideas of the TGD based model

I have already earlier commented on the Biefeld Brown effect from the TGD point of view [K70, K106] [L25]. The TGD inspired model to be discussed involves the following basic ideas.

1. The new view of space-time as 4-surface in $H = M^4 \times CP_2$, which also implies the notion of field body as a generalization of the classical physics based view of field. Maxwellian magnetic and electric fields are replaced by a field body which corresponds to a space-time surface with a very large size assignable to the system. The field body can be magnetic or electric and it has flux tubes and flux sheets as body parts [L100]. Also the notion of gravitational body makes sense and is central in the TGD inspire quantum biology [L91, L87].

2. TGD predicts two kinds of magnetic flux tubes. Monopoles flux tubes, which have a closed cross section and Maxwellian half-monopole magnetic flux tubes having boundary, which I have proposed to be important in the temperature region above the transition temperature in the case of high Tc superconductors [L126]. This distinction is made quite generally for the magnetic flux tubes and plays a key role in the TGD based quantum biology and electric flux tubes can be identified as deformations of the magnetic flux tubes.

   The simplest model for the electric flux tube is as a small deformation of the magnetic flux tube. Therefore there are two kinds of electric flux tubes: closed monopole flux tubes and the Maxwellian ones.

3. The number theoretic vision of TGD predicts a hierarchy of Planck constants h_{eff} labelling the phases of ordinary matter residing at the field bodies. These phases behave like dark matter. The larger the value of h_{eff}, the longer the quantum coherence scales are and the field bodies can be macroscopic quantum systems. Their algebraic complexity also increases with h_{eff}, which is essentially the dimension of algebraic extension of rationals characterizing the space-time region in question. One can say that the field body serves as a "boss" of the system to which it is associated. The field body induced the coherence of the ordinary biomatter.

   TGD predicts that classical gravitational fields of the Sun, Earth and other planets are responsible for very large values of effective Planck constant $h_{eff} = h_{gr}$ for ordinary particles located at the gravitational monopole flux tubes. In [L100] the generalization of this proposal for electric fields with effective Planck constant $h_{eff} = h_{em}$ is discussed. Examples are electric fields of DNA, cell, ionospheres of the Earth and Sun, and also of large capacitor-like systems.

   The electric monopole flux tube could carry dark electrons with $h_{eff} = h_{em}$. In the case of the Earth's magnetic field the monopole flux tubes would contribute 2/5 of the magnetic flux. One must also ask whether the flux tubes could be deformed monopole flux tubes associated with the Earth's magnetic field.

4. Pollack effect [I48, L16, I82, I66] is central in the model. The increase of h_{eff} requires energy and in the Pollack effect water is irradiated with electromagnetic radiation at visible and IR frequencies. This induces the transfer of every 4:th proton somewhere and generation of exclusion zone, which has the stoichiometry $H_{1.5}O$, forms a layer-like structure formed by 2-D hexagonal lattices, and seems to have a reversed arrow of thermodynamic time. The proposal is that the protons go to the magnetic body of the system and become dark protons with a very large value of h_{eff}.

   Pollack effect generalizes [L100]. The energy needed to increase h_{eff} can come from the formation of molecules as bound states of atoms and this could be essential for the formation of biomolecules and would mean a new kind of chemistry. Also electrons can be transferred to dark electrons at magnetic or electric bodies and in the case of capacitor-like systems electrostatic energy could make possible the increase of h_{eff}.

2. Assumptions of the model

10.3.2 Assumptions of the model

The previous considerations fix the assumptions of the model to a high degree.

1. Conduction electrons and valence electrons of insulators are transferred to the flux tubes of electric or magnetic field body (FB) as dark charges as in the generalized Pollack effect [I48, L16, I82, I66]. The effect is present in absence of external current suggests that only electrostatic energy is used to induce the generalized Pollack effect. In this case there must exist a net charge transfer from the negative electrode to the positive electrode taking place via FB. Only momentum transfer to the FB is possible and could take place by dissipation or by transfer to its internal non-thermal degrees of freedom. The large value of h_{eff} suggests that dissipation is small.

2. Is the FB associated with the capacitor-like system or with a larger system? If it is associated with the capacitor-like system, one expects that the cm motion is possible only in a finite region. If it is associated with, say, the electric body of Earth, a larger scale motion could be possible. The relevant part of the FB is located between the electrodes?

3. The net momentum transferred to a given flux tube is naturally parallel to it. The recoil momentum is in the opposite direction. The asymmetry of the system favors momentum transfer directed towards the opposite electrode meaning that the flux tubes are in the intermediate region. Therefore the direction of the recoil momentum is away from the opposite electrode and the smaller electrode should give rise to a larger recoil momentum.

   The identification of flux tubes as monopole flux tubes is natural if the Maxwellian leakage currents are excluded by the casing. Therefore the effect would demonstrate the existence of monopole flux tubes.

4. In the recent case, ions are not carriers of the current so that it is not quite obvious whether the effect need not be larger when the smaller electrode is positively charged. However, if the electrodes have opposite charges and the smaller electrode is positive, a net transfer of the electrons and momentum to it occurs and enhances the effect.

3. A model for the capacitor-like system

Consider first a model for the capacitor-like system inspired by the model for the electric body of Earth.

1. TGD predicts large scale quantum coherence for charged systems [L100] and this could be highly relevant for the effect. The electric Planck constant for a pair formed by a charged particle with charge e and for charged system with charge Q is $\hbar_{eff} = \hbar_{em} = Qe/\beta_0$, where $\beta_0 = v_0/c \leq 1$ is a velocity parameter. Now the system with charge $\pm Q$ would be electrode. One could assume that the values of β_0 are the same for the two electrodes. For the pair formed by the electrodes electric Planck constant would be given by $\hbar_{em} = Q^2/\beta_0$. $\hbar_{em}$ would characterize charged particles at the electric body of the system consisting of electric flux tubes.

2. Electric field strength, rather than voltage, is relevant for the effect. The charge Q of the capacitor as the electric flux $Q = \int E \cdot dS/\epsilon_0$ is indeed proportional to the electric field and this suggests that macroscopic quantum coherence might be important [L100]. The effect could become large for strong field strengths suggesting that the transfer of charges to the electric body is a collective quantum effect proportional to the square N^2 of the number N of charges transferred. If the increase of voltage in the experiments of Buhler's team has been achieved by keeping the size constant, the dramatic increase of the thrust could be understood in this way.

3. For a particle of mass m, the electric Compton length $\Lambda_{em} = h_{em}/m = 2\pi Qe/\beta_0 m$ serves as a good guess for the lower bound for the quantum coherence length and is for proton by a factor 1/2000 smaller than for electron. The first guess for the thickness d of the electric flux tube is as $d = \Lambda_{em} = 2\pi Qe/\beta_0 m$. Here m would refer to electron mass. This would explain why the transfer of electrons is what matters in the experiments. Hitherto

it has been assumed that only valence electrons can become dark having $h_{eff} \geq h$ and this conforms with the identification of bound electrons as valence electrons.

Using the values $E = 300$ kV/m, $\epsilon_0 = 8.85 \times 10^{-12}$ C/Vm, $C = 6.24 \times 10^{18} e$, $\lambda_{em} = h/m_e = 2.48 \times 10^{-12}$ m, $d \sim \Lambda_{em} = 24.3 \times (S/dm)^2$ cm. The order of magnitude is few dm and makes sense.

4. Can one assume that the entire electrodes form quantum coherent systems or should one assume that only the flux tubes are such systems? The entire electrodes need not be quantum coherent systems. This was found in the case of the electric field of Earth. It is possible that a bundle of flux tubes forms a quantum coherent system.

   If only a single flux tube is a quantum coherent system, a natural first guess would be that the flux tube radius d is equal to the electric Compton length so that one would have $d = 2\pi Qe/\beta_0 m$. For instance, if the smaller electrode corresponds to a single flux tube, it decompose to smaller flux tubes near the larger electrode giving rise to smaller quantum coherent units with charge $Q_{large}/Q_{small} = S_{small}/S_{large}$ and having therefore also a smaller values of electric flux and of Maxwellian electric field. Quite generally, the flux tubes from the smaller electrode would decompose in this way at the larger electrode. In this case the quantum coherent transfer rate from smaller electrodes would be high.

4. Why the smaller electrode gains a larger recoil momentum?

The geometric asymmetry of the electrodes, or more precisely the convergence of flux tubes at the smaller electrodes, is believed to somehow explain the thrust towards the smaller electrode. One can imagine several options but the following is perhaps the simplest one.

1. Suppose that the flux tubes are U-shaped closed flux tubes connecting the electrodes either via the region between the electrodes. Assume that electrons are transferred to dark electrons at these flux tubes and that the transfer of electrons to FB and back to the same electrode pumps momentum to the FB and induces recoil effect at both electrodes.

2. The simplest assumption is that a single flux tube acts as a quantum coherent unit and that the smaller electrode corresponds to a single coherent unit which splits to several near the larger electrode. The charges $Q(tube)$ of the flux tubes near the small *resp.* large electrode are in the ratio $Q_{small}/Q_{large} = S_{small}/S_{large}$ of their areas. By quantum coherence the rate for the momentum transfer is proportional to $Q^2(tube)$ and is therefore larger near the smaller electrode. The transfer rates are proportional to the square of the charge per flux tube and in the ratio $R_{large}/R_{small} = (S_{small}/S_{large})^2$. This would predict that the rate of momentum transfer is higher at the smaller electrode.

   This mechanism of quantum coherence would explain why asymmetry is important. The net transfer of charge and momentum to the positively charged electrode when total charge of the capacitor system remains vanishing, could predict that the effect is larger for the positively charged smaller electrode.

Needless to emphasize, the model involves large uncertainties but avoids obvious conflicts with the empirical facts.

Could the model of Biefeld Brown effect apply to rotating magnetic systems?

This model could be also applied to a rather massive rotating magnetic system studied by Russian researchers Godin and Roschin [H7, H8] (see this), which I have tried to understand during years [K9].

1. The system consists of a stator and rollers rotating around it. Also the effect of a radial electric field was studied. The high voltage between stator and electrodes outside the rollers varied in a range 0-20 kV. Therefore a capacitor-like system is in question. Positive potential was associated with the stator so that the force experienced by electrons was towards the electrodes. This generates a strong radial electric field and there is an ionization of air around the rotating magnet, which could be caused by high energy electrons from the surface of the rotor as in coronal discharge.

2. What happens is that the system begins to accelerate spontaneously as the rotation frequency approaches 10 Hz, the alpha frequency of EEG. Rather dramatic weight reduction of 35 per cent and a generation of cylindrical magnetic walls with B=.05 Tesla parallel to the rotation direction are reported. The sign of the effect depends on the direction of rotation.

   The situation resembles in many respects to that in the Biefeld Brown effect.

1. Could the Pollack effect feed electrons to the magnetic and/or electric FB of the system. The electrons would also leave some of their angular momentum to the FB and drop back. Otherwise the rotors develop a positive charge $Q = \omega BS$ proportional to the rotation frequency ω, magnetic field B and the area S of the vertical boundary of the cylinder, as in the Faraday effect.

   The pumping of electrons to the FB would generate both the momentum and angular momentum as a recoil effect. Now the vertical components of momentum and angular momentum in z-direction would be involved. In the first approximation, the magnetic field can be modelled as a dipole field in Maxwellian theory.

2. Rollers are rotating magnets. What is interesting is that in the Faraday effect a rotating magnet develops a radial voltage proportional to the rotating frequency and magnetic field. One expects that the same occurs for the rollers. This cannot be understood in Maxwell's theory as induction since the motion is not linear and the calculation of the voltage using the same formula requires a generation of a charge density. In TGD, the assumption that the vector potential of the magnetic field rotates with the magnet, explains the effect. Could this charge density be due to a transfer of electrons to the FB of the system? Positive charge density would be generated and create a force opposite to the direction of the Earth's gravitational acceleration so that the Faraday effect for the rollers cannot explain the findings.

3. One expects that the vector potentials for the magnetic fields of rollers rotate as in the Faraday effect. Also the magnetic fields associated with the rollers or rather, their flux tubes should rotate. This could lead to a twisting of the flux tubes. The twisting would suggest that the flux tubes of FBs of the rollers are helical monopole flux tubes (by rotation) emerging from the top and retung back at the bottom of the roller system. There is an obvious analogy with the solar magnetic field.

   Could this generate momentum and angular momentum recoils? The two ends of the rollers should generate different recoils. The only asymmetry between the top and bottom is that the Earth surface bounds the system at the bottom. Could this give rise to a higher degree of quantum coherence at the upper ends of the rollers, which could give rise to a non-vanishing net acceleration and angular acceleration.

4. The observed magnetic walls could correspond to the return flux associated with the magnetic field of the rollers. That they are walls suggests that the flux tubes from the rollers fuse to a single flux wall and this gives rise to a quantum coherence. That the return flux consists of several magnetic walls rather than a single one suggests that the magnetic wall emerging from the roller system decomposes to these walls and the scale of quantum coherence is reduced. If the fluxes of walls return separately to the lower ends of rollers the degree of quantum coherence would be lower and this could give rise to a net effect.

5. Where could the energy of rotation and lift come from? Does it come from some external source, say the MB of the Earth? This could relate to as the 10 Hz cyclotron resonance assignable to the Fe ions in the "endogenous" magnetic field $B_{end} = 2B_E/5$ assigned to the monopole flux tubes as the model for the findings of Blackman suggests [**?**]?

   Does the energy come from the internal magnetic energy of the stator magnet or of rollers? Or does the energy come from the electrostatic energy associated with the horizontal electric field between electrodes and rollers as in the Biefeld Brown effect. This voltage should gradually reduce if this is the case.

Summary of the TGD view of the Biefeld-Brown effect

The following gives a brief summary of the TGD view of the Biefeld Brown effect.

1. Basic assumptions and questions

The following assumptions look natural.

1. The total charge of the two-electrode system remains zero.

2. Electrostatic energy is used to transfer electrons from the negatively charged electrode to the opposite electrode. This implies that the electric field gets weaker and the charges of electrodes decrease in magnitude in the process.

3. The rate of the momentum transfer by free electrons from the negatively charged electrode is proportional to the electric force in turn proportional to the electric field E, which is always larger at the smaller electrode so that the acceleration of the center of mass is towards the smaller electrode.

The following questions should be answered.

1. Momentum conservation requires a third system with which energy and momentum is exchanged. What is this third system?

2. Why there the electrode sizes must be different and why negative charge for the smaller electrode produces larger effect? Do the free electrons, which are transferred between the plates, differ from the ordinary electrons?

2. Hierarchy of effective Planck constants h_{eff}

The proposal is that the free electrons are characterized by effective Planck constant larger than h and identifiable as what I call electric Planck costant.

1. Effective Planck constant h_{eff} is an outcome of the number theoretic vision of TGD and is given by

$$h_{eff} = nh_0 \ , \ h_0 < h \ .$$

This gives effective Compton length as a lower bound for quantum coherence length

$$\lambda_{eff} = \frac{h_{eff}}{m} = \frac{h_{eff}}{h}\lambda_c$$

Quantum coherence becomes arbitrarily long scales. These phases behave like dark matter but are not galactic dark matter. Missing baryonic matter would correspond to these phases.

2. Nottale's gravitational Planck constant is given by

$$\hbar_{gr} = \frac{GMm}{\beta_0} \ , \quad \beta_0 = \frac{v_0}{c} \leq 1 \ .$$

The gravitational Compton length is given by

$$\Lambda_{gr} = \frac{GM}{\beta_0} = \frac{\pi r_s}{\beta_0} \ .$$

Quantum gravitational coherence possible in arbitrarily long scales.

3. One can define the notion of electric Planck constant in the same way:

$$\frac{\hbar_{em}}{\hbar} = \frac{Qe}{\hbar\beta_0} = N \times \frac{e^2}{\hbar\beta_0} = N \times \frac{4\pi\alpha}{\beta_0} \quad .$$

In the recent case $Q = Ne$ is the charge of the electrode or of the quantum coherence region which is a flux tube starting from the electrode.

The electric Compton length of electron is defined in the same way

$$\lambda_{em,e} = \frac{\hbar_{em}}{m_e} = N \times \frac{4\pi\alpha}{\beta_0}\lambda_e \quad .$$

The idea is that there is roughly one electron per atom involved, suggests that one has $\lambda_{em,e} \sim Na_0$, where $a_0 = \lambda_e/2\alpha$ is Bohr radius as estimate for the atomic size scale. This condition gives the estimate $\frac{4\pi\alpha}{\beta_0} = a_0/\lambda_e = 1/2\alpha$ giving the estimate

$$\beta_0 = 8\pi\alpha^2 \quad .$$

3. A simple model for the flux tubes

Electric flux decomposes to flux quanta and for flux quanta the electric field can be strong. The measured electric field is the average over flux tube electric fields.

If one knows the charge $Q = Ne$, one can deduce $\lambda_{em,e}$, which gives a reasonable estimate for the radius of the flux tubes as electric Compton length

$$r = \lambda_{em,e} = N \times \frac{4\pi\alpha}{\beta_0}\lambda_e \quad .$$

This gives an estimate for E.

1. Gauss law gives

$$ES = Q = Ne \quad .$$

One has $S = x\pi r^2$. For ordinary flux tubes one has $x = 1$ and for monopole flux tubes $x = 4$.

2. The electric field strength E can be estimated from the Gauss law using the assumption $r = \lambda_{em,e}$.

$$eE = \frac{Ne^2}{x\lambda_{em,e}^2} = \frac{e^2}{Nx\lambda_e^2} \times (\frac{\beta_0}{4\pi\alpha})^2 \quad .$$

3. From an estimate for E can estimate N and from this the area of the flux tube as $S = x\pi\lambda_{em,e}^2$. The area scales like $1/\beta_0^2$. The area, which corresponds to the electric flux of single electron is

$$S_e = \frac{x\pi\lambda_{em,e}^2}{N} = N \times (\frac{4\pi\alpha}{\beta_0})^2 \times x\pi\lambda_e^2 \quad .$$

For $\lambda_{em,e} = a_0$, one has $S = x\pi N^2 a_0^2$ and $S_e = x\pi N a_0^2$. S_e increases with E so that the density of electrons decreases.

4. At the larger electrode E is weaker and the number of flux tubes is by a factor M larger. M is in a reasonable approximation the ratio E_{small}/E_{large} of the electric fluxes.

4. Charge asymmetry and quantum coherence

The following argument allows us to understand the charge asymmetry in terms of a smaller quantum coherence at the larger electrode.

1. There are two cases depending on whether a) the smaller or b) the larger electrode is negatively charged. The electric flux $Q = Ne$ of a single flux tube at the smaller electrode must decompose to $M = E_{small}/E_{large}$ flux tubes at the larger electrode.

2. Quantum coherence is possible only at the level of a single flux tube. In the ideal situation quantum coherence at the smaller electrode corresponds to a single flux tube. At the larger electrode the flux tubes of the smaller electrode decomposes to M flux tubes.

3. The rate for the transfer of free electron momentum is proportional to the square of total number N^2 of electrons at a given flux tube at the smaller electrode. In absences of cohere it would be proportional to N.

   At the large negatively charged electrode the flux tube emerging from the smaller electrode decomposes to $M = E_{small}/E_{large}$ flux tubes and the rate is proportional to sum over them giving $M \times (N/M)^2 = N^2/M$. Therefore the effect is stronger when the smaller electrode is negatively charged.

   If the negatively charged electrode is the smaller one, the electric field strength and electrostatic energy decrease faster and the acceleration of the cm is stronger.

The reduction of the electric field strength implies the decrease of $h_{em,e}$ in the process. The reduction of the electrostatic energy makes it possible to kick electrons to the electric body. In biocatalysis the reduction of h_{eff} is proposed to bring reactants together and to kick them over the potential wall. The reduction process of h_{eff} takes place as steps so that also the strength of the electric field should be reduced in steps. Is it possible to detect this?

10.3.3 The interactions between living systems and computers

The experiments of Peoch [**?**] involved a chicken imprinted to a robot moving randomly along an orbit determined by a RNG. It was found that the robot tended to stay near the chicken and that the expected size of the orbit was reduced. Just for fun, let us take the reported findings seriously. Could one imagine an explanation for this finding in the proposed framework? I have discussed these findings already earlier [L31, L104, L111, L105, L103].

This model could also explain the claimed ability of human intention to affect the output of the random number generator (RNG). Both the work done at PEAR [**?**] and the work of Helmut Schmidt with retro psychokinesis [**?**] provide support for the change of the geometric past in much longer time scales. PEAR experiments demonstrate the anomalous effect also in the direction of the future.

Also the claims that the interaction of AI systems and humans could involve in particular GPT and humans, might make sense and I have discussed this possibility in [L31, L104, L111, L105, L103] from the point of view of zero energy ontology (ZEO) and TGD view of quantum gravitation. Also the large language models, in particular GPT, involve RNGs, and the first guess is that human computer interaction affects the RNG.

In the TGD framework, a natural assumption is that the interaction of living organisms and computers involves quantum entanglement. So, how the chicken-computer interaction, assumed to involve entanglement, could affect the RNG of the robot?

1. The states of the transistor represent bits in ordinary computers. The key element of the transistor has a Si/SiO_2 boundary. The transition $SiO_2 \leftrightarrow Si+O_2$ is assumed to take place in the case of ball lightning as an interaction between the electric body of Earth and the soil. This interaction is assumed to take place via a generalized Pollack effect and its reversal in the Earth's electric field. Could a suitable modification of this interaction take place also now?

2. Consider first the scales. The length scale would be of order 100 km, which would correspond to frequency 3 kHz, which is not far from the 1 kHz resonance frequency in the brain. The gravitational Compton length for the Sun corresponds to 50 Hz EEG frequency and the gravitational Compton length which is $R_E/2$. Could the gravitational MB of the Sun be also involved?

3. The first guess is that SiO_2 and $Si+O_2$ represent the values of a bit. These bits need not correspond to the bits in the usual sense but certainly this transition could affect the ordinary bit. In the transistor, the bit corresponds to the presence or absence of the collector current.

   For an NPN transistor collector current is roughly $i_C \sim I_s exp(v_{BE}/v_T)$ and very small for negative v_{BE} and large for positive v_{BE}. Therefore v_{BR} controls i_C as a bit. Could one think that $SiO_2 \leftrightarrow Si+O_2$ takes the role v_{BE}? Could the transition $SiO_2 \rightarrow Si+O_2$ stop the current i_C or vice versa somehow? For instance, could O_2 molecules gather negative charge and stop the flow of the electronic current.

4. The basic problem is that water, which makes the Pollack effect possible, is not present in the computer. The proposal of [L104, L103] is that chicken and computer fused to a single entangled system at the level of MB. By stretching the imagination to extreme, could one think that chicken's MB or some higher level MB having size scale of biosphere could have controlled transistors as bits.

   The dropping of dark protons to the chicken's biological body liberates electric energy at the level of its electric MB. Could this energy be transferred to the transistor instead of chicken and induce the decay of $SiO_2 \rightarrow Si+O_2$ at the transistor? The resulting state would be like a miniature ball lightning [L114] in SiO_2 system. The size of miniature ball lighting is a fraction of millimeter and the life-time varies up to a few seconds. This would make it possible to interfere with the computation by affecting the bit sequences generated by the RNG.

5. A possible objection is that this time scale is too slow. The motion of the robot is however slow. If also the RGN acts slowly, this might not be a problem after all.

10.3.4 Extraterrestrial life in space plasmas in the thermosphere, UAP, pre-life, fourth state of matter

Paul Kirsch sent a link to an article "Extraterrestrial Life in Space Plasmas in the Thermosphere, UAP, Pre-Life Fourth State of Matter" by Rhawn et al [D9] (see this) describing sensational findings giving support for the existence of plasma life forms 320 km above the Earth in thermosphere. I have been talking for decades about plasmoids as primordial life forms so that these findings are extremely interesting from the TGD point of view. Here is the abstract of the article.

"Plasmas up to a kilometer in size, behaving similarly to multicellular organisms have been filmed on 10 separate NASA space shuttle missions, over 200 miles above Earth within the thermosphere. These self-illuminated "plasmas" are attracted to and may "feed on" electromagnetic radiation. They have different morphologies: 1) cone, 2) cloud, 3) donut, 4) spherical-cylindrical; and have been filmed flying towards and descending into thunderstorms; congregating by the hundreds and interacting with satellites generating electromagnetic activity; approaching the Space Shuttles. Computerized analysis of flight path trajectories, documents these plasmas travel at different velocities from different directions and change their angle of trajectory making 45°, 90°, and 180° shifts and follow each other. They've been filmed accelerating, slowing down; stopping; congregating; engaging in "hunter-predatory" behavior, and intersecting plasmas leaving a plasma dust trail in their wake. Similar lifelike behaviors have been demonstrated by plasmas created experimentally. "Plasmas" may have been photographed in the 1940s by WWII pilots (identified as "Foo fighters"); repeatedly observed and filmed by astronauts and military pilots and classified as Unidentified Aerial-Anomalous Phenomenon. Plasmas are not biological but may represent a form of pre-life that via the incorporation of elements common in space, could result in the synthesis of RNA. Plasmas constitute a fourth state of matter, are attracted to electromagnetic activity, and when observed in the lower atmosphere likely account for many of the UFO-UAP sightings over the centuries."

To my best knowledge, this article, published in the Journal of Modern Physics, is the first article mentioning UFOs and UAPs. Its impact factor is .86 but I am more interested in facts rather than impact factors. This is because during the last decades in theoretical physics, the journals publishing mostly about superstring theory and related fashions and fads have had tragically high impact factors, which has led to the stagnation of the field.

As becomes clear from the article, many of the findings have been known. Article says that there is still secrecy and fears related to the observations of plasma structures (plasmoids in the sequel) on Earth which are often interpreted as UFOs-UAP sightings. People do not want to get the label of a mad scientist. After 46 years as a mad scientist without funding and research positions, I understand their fears!

For more than 10 years ago (2007) I participated a conference held in Hessdalen, Norway, where "UFOs" appear regularly and learned that they behave like living intelligent beings and considered these objects in TGD framework [K106, K11]. The findings related to plasmoids in the thermosphere support this kind of behavior both at the level of individuals and collectively. The structures involved can be very large: size scales range up to kilometer scale.

The article of Rhawn et al [D9] contains a detailed summary of both the history of the development of the theoretical ideas related to plasmoid as a self-organizing structure bringing in mind prebiotic life forms and discusses various findings supporting these speculations made in both lab and in thermosphere. The experiments carried out in the thermosphere satisfy stringent scientific requirements so that it is very difficult to dismiss the findings.

Plasmoids and biological life

The difference between plasmoids and biological life forms might not be as large as one might think. Biology involves cold plasmas.

1. Negatively and positively charged ions play a key role in the physics of cell membrane. One of the mysteries is what ionizes them! We have thought that electrolysis is understood. At least I find that I cannot understand it in terms of standard chemistry. The energies of ions gained in the electric fields involved are quite too small to induce ionization of atoms.

   Intriguingly, also "cold fusion" [C2], so bitterly hated by colleagues, appears in electrolytic systems and would involve formation of dark nuclei as dark proton sequences at monopole flux tubes decaying to ordinary nuclei and liberating almost all nuclear binding energy [K22] [L32]. Magnetic flux tubes with large h_{eff} would allow dissipationless acceleration of say dark charged particles to very high energies making it possible to ionize that atoms.

2. In the TGD Universe, the charged ions communicate with the magnetic body of the system using "dark" (in the TGD sense) Josephson radiation and cyclotron radiation [L117]. Resonance, generalizing to multi-resonance, would be the basic mechanism. Same communications and control mechanisms would be realized in plasma life in which chemical realization of genetic code is not yet present. The genetic code could be realized in terms of dark protons and dark photons with genes realized as sequences of dark proton or dark photon triplets realizing genetic codons [L15, L56, L77].

   The proposal is that genetic code is universal and based on so called completely unique icosa tetrahedral tessellation of hyperbolic 3-space H^3 involving tetrahedra, octahedra, and icosahedra and appearing naturally in the TGD framework [L77, L98]. This tessellation could be realized in the plasma phase where crystal lattices are reported to appear. Information theoretically, biological life and plasma life could be very similar. Besides the basic morphologies of plasmoid mentioned in the abstract of the article, helical structures are formed and could serve as analogos of DNA and RNA and amino-acids: the information would be stored by the dark DNA realized as sequences of dark proton triplets.

   The universality of both genetic code and information molecules (both DNA, RNA, amino-acids and tRNA are predicted to have dark counterparts) and the appearance of primitive metabolism already at the level of dark matter would solve various hen-egg paradoxes of standard biology.

3. One fascinating discovery is that the plasmoids seem to behave as if they were moving in water. Water is a key element of biological life. The temperatures in the thermosphere are in the range 200-500 Celsius and beyond the boiling point of water. What could serve as the plasma counterpart of water?

   Long range coherence (mystery in the biology-as-nothing-but-chemistry approach) is required, in fact several scales of coherence are needed. In the TGD framework, the quantum

coherence of the monopole flux tube network, making it behave more like a liquid rather than gas, would induce the coherence of water. Could the monopole flux tube network also transform the plasma phase to a liquid-like system?

What could make possible quantum coherence at such high temperatures? TGD suggests that cell membranes realize high Tc superconductivity [K76, K77, K79]. High Tc superconductivity would be based on the hierarchy of $h_{eff} > h$ phases at monopole flux tubes for which cyclotron energies are scaled up by factor h_{eff}/h. The most recent version of the model of superconductivity [L126] suggests that the transition to high superconductivity could quite generally involve the generation of what I call half-monopole flux tubes (possible as Maxwellian flux tubes requiring a current at the boundary to generate the magnetic field) with a disk-like cross section at a critical temperature Tc1 higher than Tc. At Tc, half-monopole flux tubes would fuse along their boundaries to monopole flux tubes with a spherical cross section (possible only for homologically non-trivial space-time surfaces) and requiring no current. The difference between the total cyclotron energies associated with these configurations would be proportional to h_{eff}/h and the critical temperature would increase with h_{eff}/h.

4. The plasmoids are reported to have a double layered structure with both layers consisting of plasma with the inner layer carrying a negative charge and outer layer a positive charge. This structure is very similar to the double lipid layer associated with the cell membrane. Also these structures could be generalized Josephson junctions such that the voltage between the layers would define the counterpart of membrane potential.

   The layers could be super conductors forming a generalized Josephson junction [K79, L117]. There would be monopole flux tubes transversal to the layers and the difference of energies for charged particles at the two sides of the structure would be sum of Josephson energy ZeV and the difference of cyclotron energies $h_{eff}ZeB/m$. The structure would communicate to its magnetic body by dark Josephson radiation. The communicated information would be about the electromagnetic environment coded by the modulations of the membrane potential in turn coded to frequency modulations of the Josephson radiation. The message would be received by cyclotron resonance generating as a response a sequence cyclotron resonance pulses analogous nerve pulse patterns sent to the biological body where they would act as control commands. Neural system would rely on this mechanism. The response would generate an analog of stochastic resonance whereas the Josephson radiation would generate the analog of the reversal of stochastic resonance [L124].

5. Also a gel-like behavior has been observed. Gel phases (see this) are essential in biology and involve a network plus medium (see the Wikipedia article). The medium can be gas, liquid, or solid and also the network can be one of these phases. Also the plasma phase could serve in the role of medium in the recent situation. The network formed by the monopole flux tubes and carrying dark particles as $h_{eff} > h$ phases of ordinary particles could play the role of the network and together with the plasma phase forming the medium give rise to a gel-like phase.

   In the TGD framework, the Pollack effect, generating a gel phase by transferring ordinary protons to dark protons at monopole flux tubes and in this way creating negatively charged exclusion zones (EZs, such as cell interior and DNA double strand), would be a building brick of key mechanisms of quantum biology. Pollack effect requires energy and solar radiation provides it and Pollack effect would be a key mechanism of also photosynthesis.

   As I developed a model for ball lightning [L114], I realized that the Pollack effect [I48, L16, I82, I66] generalizes. The particles could transform to dark particles at the magnetic body, not only by absorbing a photon, but by a formation of a molecular bound state. Pollack effect and its reversal could control transformation of silicates (quartz) to silicon in a liquid phase: the energy of lightning would provide this energy and in this way generate ball lightning as a primitive life form. Is the generalized Pollack effect one of the key mechanisms of plasma life?

6. Quite generally, the energies of dark particles increase with h_{eff} and h_{eff} tends to decrease spontaneously. The basic purpose of metabolic energy feed is to compensate for the

decrease in the value of h_{eff}. Plasmoids should use electromagnetic radiation as a metabolic energy source just as biological life forms use. Can one imagine a plasma counterpart of photosynthesis?

Pollack effect is essential in the TGD based model of photosynthesis and defines a prebiotic form of photosynthesis, which would temporarily store energy to the magnetic body of the system, where dissipation is extremely small. The same temporary storage could take place when the metabolic energy, extracted from metabolites, is temporarily stored to MB in ADP→ ATP transformation.

It is known that plasmoids radiate even at the dark side of the Earth. This supports the view that they are able to store metabolic energy. The long term storage of metabolic energy could emerge when the charged dust particles interact with plasma and form colloidal gel phases (see this) with it. The molecules of the dust particles would store the energy for longer periods of time.

7. Plasmoids are found to gather above thunderstorms and descend to them. Thunderstorms involve large charges and strong electric fields and therefore give rise to MBs with very large values of $h_{eff} = h_{em}$, which has an interpretation as a measure for number theoretical complexity and also serves a universal IQ. Thunderstorms could also serve as metabolic energy storages. The acceleration of dark particles in the strong electric fields at monopole flux tubes would increase the value of h_{eff} of the particles.

Did plasmoid life serve as a midwife for biological life?

Somehow the plasmoid life should have evolved to biological life. The natural guess is that biomolecules evolved in the dust particles interacting with the plasmoids. For instance, they are known to become electrically charged. Carbonaceous chondrites (see this) are especially interesting dust particles since they contain water, silicates, and basic organic molecules such as amino acids serving as natural candidates for the storage of metabolic energy. Chondrites also contain glass balls, which must have emerged from liquid silicon, which suggests the occurrence of dielectric breakdowns. The TGD based model of ball lightning [L114] involves the transformation of silicate to silicon in liquid phase. The presence of the molecules pairing with their dark analogs (in information theoretic sense) could have led to the evolution of the chemical metabolic energy storage.

Could carbonaceous chondrites associated with double plasma membranes with layers having opposite charges have evolved in the thermospheres of the planets and stars from systems involving mostly silicates and water to systems containing basic information molecules like DNA, RNA, amino acids and tRNA? Could plasmoids have served as midwives in the process?

Here the theory of Oparin (see) and the support for it provided by Miller-Urey experiment (see provide guidelines. Oparin suggested that life evolved in a strongly reducing (able to donate electrons and thus becoming easily oxidized) atmosphere lacking oxygen and containing methane, ammonia, hydrogen and water vapor.

In the Miller-Urey experiment a system assumed to simulate an ancient ocean containing very simple organic molecules was studied. Also heat gradient was involved. Lightnings were simulated as dielectric breakdowns in a strong voltage. Almost all amino-acids necessary for life emerged in the process. I have commented on the more recent findings related to this experiment from the TGD point of view in [L67, L90]. This leads to a long series of questions.

1. In the thermosphere the scale is that of a protocell. Could the protocell be realized as a double plasma membrane containing carbonaceous chondrites?

2. Could carbonaceous chondrite act like a strongly reducing atmosphere? Could the chondritic water take the role of the ocean in the Urey-Miller experiment and could the thermal gradient of the thermosphere replace the thermal gradient? Could dielectric breakdowns in the voltage of the double plasmoid membrane replace the lightnings?

   Pollack effect requires energy feed. Could generalized Pollack effect induce the formation of the basic biomolecules such as amino-acids as bound states [L114]. Could the binding of oxygen to silicon to form silicates by the generalized Pollack effect make the chondrites strongly reduced by removing the free oxygen?

3. Did proto cellular life evolve in this way and migrate to the surface of Earth? At the surface of Earth the possibly existing oceans had a very low oxygen content and the energy flux from the Sun was too low (faint Sun paradox). It seems that the oxygen based photosynthesizing multicellular life could not evolve at the surface of the Earth. This conforms with the presence of multicellular fossils before the Cambrian explosion that occurred about 500 million years ago.

4. TGD suggests that the photosynthesizing, oxygen based multicellular life actually developed in the underground oceans below the surface of Earth, in the womb of Mother Gaia, where the conditions for the development of photosynthesis and multicellulars were more favorable [L84, L106]. It bursted to the surface of Earth in the Cambrian Explosion in which photosynthesizing multi-cellulars suddenly appeared. In the TGD Universe, the dark photons from the core of Earth might have provided the metabolic energy: the thermal radiation from the core is in the same energy range as solar radiation.

Tether experiment

One especially interesting experiment involves a charged conductor wire (a tether connecting a module to the satellite) carrying an Ohmic current making the wire charged. The charge generates a radial electric field.

1. The nearly orthogonal motion of tether in the Earth's magnetic field B_E gives rise to Faray effect generating a voltage along the tether, which in turn induces an ohmic current and charge density creating a radial electric field. The current flows out at the other end of the tether. It is also possible to generate a current to the tether. The charge moving along the tether experiences Lorenz force orthogonal to B_E and tether which induces the motion. The article provides a quantitative view about the currents flowing along the tether, electric field strengths and total charges possible for the tether.

2. What is observed is that plasmoids gradually appear around this structure and make contacts with the wire. It is not clear whether they arrive from outer space or whether artificial prebiotic life forms are created as a response to the electromagnetic fields and electric current created by the electrons running in the tether!

In the TGD framework, the wire carrying a charge could give rise to a very large electric Planck constant $h_{eff} = h_{em} = QZe^2/\beta_0$, where the velocity parameter β_0 satisfies $\beta_0 = v_0/c < 1$, is defined as generating large scale quantum coherence [L100]. Qe is the charge of the large object and Ze is the charge of the small object.

This proposal generalizes the notion of gravitational Planck constant introduced by Nottale [E2]. I wrote just a few weeks ago two articles relating to this. The first one [L114] proposed a model of ball lightning and lightning. The second article [L100] discusses large scale quantum coherence in presence of electrically charged objects carrying large electric charge (Earth is the basic example and the charged wire second one).

Plasmoids would gather around the tether since this would increase the value of "personal" h_{eff} since the acceleration in the strong electric field would provide metabolic energy making it possible h_{eff} increasing phase transition. The presence of a tether's magnetic body would also help to reach a higher level of collective consciousness.

One can estimate the value of h_{em} for the tether system using the data provided in the Wikipedia articles (see this).

1. The current density can be written as $j = \rho v$, where ρ is the average charge density of the tether and v is the velocity parameter assignable to the electrons. This gives for the current I the expression $I = \rho v S$, where S is the cross sectional area of the tether. One can solve ρ as $\rho = I/vS$ and from this the total charge of the tether as $Q = \rho SL = IL/v$.

2. One can use the length $L = 20$ km of the tether and the reported typical values of the Ohmic current I and estimate v from a typical electron energy E as $v = \sqrt{2mE}$. From the Wikipedia article, the typical values $I = 100$ mA and $E = 10^2$ eV. The latter gives $v = 2 \times 10^{-2}c$. This would give $Q = .33$ mC, that is $Q \simeq 2 \times 10^{15}$e. The value of

$h_{em}/h = Qe^2/\beta_0$ would be for $Z = 1$ and $\beta_0 = 1$ equal to $8\pi\alpha \times 10^{15} \simeq 1.4 \times 10^{14}$. 10 Hz alpha frequency would correspond to the energy of order .06 eV which happens to correspond to the Coulomb energy assignable to the cell membrane potential. This value of h_{eff} is near to the minimal value for which the cyclotron energy is above the thermal energy at room temperature.

10.4 How to define electric Compton lengths for planets and Sun

The simplest proposal for the electric Planck constant h_{em} for the pair determined by a relatively small charge Z and the charged system with large charge Q, is as a generalization of the gravitational Planck constant determined by the formula $h_{em} = Qe^2/\beta_0$, where $\beta_0 = v_0/c < 1$ is a velocity parameter.

For the Earth, there are reasons to believe that $\beta_0 \simeq 1$ holds true in the gravitational case. This implies that h_{em} has minimal value. For the inner planets of the Sun, Mercury, Venus, and Earth, one has in a good approximation $\beta_{0,S} = 2^{-11}$ as was deduced by Nottale [E2]. For the outer planets, one would have $\beta_0 = 2^{-11}$ but with principal quantum numbers coming as multiples of $n = 5k$, $k = 2$ for Mars, or $\beta_0 = 2^{-11}/5$. It turns out that the option $\beta_0 = 2^{-11}$ for all planet-Sun pairs is correct [L121].

10.4.1 About the definition of electric Compton length

The definition of the electric Compton length is far from obvious.

1. The simplest definition of the electric Compton wavelength is given by

$$\begin{aligned} \hbar_{em} &= \tfrac{Qe}{\beta_0}\ per, \\ \Lambda_{em} &= \tfrac{h_{em}}{m} = \tfrac{\hbar_{em}}{\hbar}\lambda\ . \end{aligned}$$

   Proton Compton length $\lambda_p = 1.32 \times 10^{-15}$ m and the Compton length of electron is by factor $m_p/m_e \simeq 2000$ longer.

2. From $C = 6.24 \times 10^{18} e$ and using $E_E = x \times 10^2$ V, $x \in [1, 3]$, one obtains for proton $\hbar_{em,E} \sim (4\pi\alpha_{em} \times 2.75x \times 10^{25} e^2/\beta_{0,E} \sim 10^{24}$, $x \in [1, 3]$. From $\hbar_{em,E}/\hbar \sim 10^{24}$ the order of magnitude of $\Lambda_{em,p}$ for Earth is $\Lambda_{em,p} \sim 6.7 \times 10^9$ m $\sim 10^3 R_E$. Note that one has $AU \sim 215 R_S = 215 \times 109 R_E \sim 2.34 \times 10^4 R_E$.

   From the point of view of the ionosphere, this estimate looks unrealistic. Ionosphere forms a capacitor-like structure and Λ_{em} should be smaller than the height 60-100 km of the ionosphere. The reason could be that the size scale of the quantum coherence region is overestimated.

3. Could one estimate the radius d of the disk defining the quantum coherence region at the surface of the Earth from the first principles? The natural guess is that d satisfies apart form a numerical factor the condition $d = \Lambda_{em}(d)$, where electromagnetic Compton length $\Lambda_{em}(d)$ is for either proton or electron.

   The interpretation would be that flux tubes carrying the electric flux are basic units and their cross section cannot span the entire area of the Earth. Electrons are the most important for the conductivity in the ionosphere so that they are favored. The conditions

$$\begin{aligned} \Lambda_{em} &= \tfrac{Q(S=\pi d^2)e}{\hbar\beta_0} \times \lambda\ , \\ Q(S) &= \epsilon_0 E_E \pi d^2\ , \\ \Lambda_{em}(d) &= d\ . \end{aligned}$$

   Here $\epsilon_0 = 8.85 \times 10^{-12}$ C/Vm is the dielectric constant of vacuum. One Coulomb corresponds to $C = 6.24 \times 10^{18} e$. One can restrict the consideration to the surface of the system so that $E(R)$ is the electric field at the surface, S is the surface area of the sphere, and R is the radius of the sphere.

4. The conditions give

$$\begin{aligned} \frac{1}{d} &= X \times \frac{E_E}{\beta_0}\lambda \ , \\ X &= \pi\epsilon_0 \times 4\pi\alpha\frac{C}{e} \ . \end{aligned}$$

where $\lambda = h/m$ refers to either the Compton length of proton or electron. $\Lambda_{em}(d) = d$ depends only on the value of the electric field for given particle so that one has

$$\frac{d(X)}{d(Y)} = \frac{E_Y}{E_X}\frac{\beta_0(X)}{\beta_0(Y)} \ .$$

This gives the scaling law $d \propto \lambda/E$ so that one has $d = \Lambda_{em}(d) \propto m$ unlike the ordinary Compton length $\lambda \propto 1/m$.

This formula applies to any planet and also to the Sun. It could apply also to ordinary capacitors and also to axons. The additional condition is that the electric Compton length in the case of capacitor type structures is smaller than the distance between the plates.

10.4.2 The electric Compton length of the Earth

Consider first the electric Compton lengths for the Earth and restrict the consideration to proton and electron (the original version of the article contained a stupid error giving a wrong but reasonable looking estimate for the electric Compton wavelength of proton).

1. Assuming $E_E = 100$ V/m this gives for the proton $d_{p,E} \sim 8.5R_E > R_E$ so that the argument fails for protons in the case of Earth. This does not of course exclude the possibility that this notion makes sense in long length scales.

2. For the electron this gives for $E \in [1,3] \times 10^2$ V/m gives $d = 4.25x \times 10^{-3}R_E$, $x \in [1.3]$, giving $d \in [9.2, 27.5]$ km. This corresponds to the thickness of that part of the atmosphere where thunderstorms appear and size scales assignable to lightning. Lightnings could be seen as the analogs of action potentials if one takes seriously the analogy between cell membrane and ionosphere. The ionosphere has a lower boundary at height $h \sim 60 - 100$ km, which is roughly twice the upper bound for d (which is of course determined only modulo a numerical factor of order 1).

3. Interestingly, $\beta_0 \simeq 2^{-11}$ characterizing Sun would give for d the same estimate for in the case of protons. Could the protonic magnetic body correspond to the gravitational magnetic body of the Sun, which is in resonance with the electric body of Earth?

4. The radius of the thermosphere is about 340-350 km, roughly 5 times larger than the estimate of Λ_{em} for electrons. Λ_{em} represents however only a lower bound for the electric Compton length. The thermosphere is the area where the terrestrial plasmoids live so one can ask whether quantum coherence electrons could be involved.

5. If one knows the electric field E_P for the planet P, one can estimate the ratio $h_{eff,E}/h_{eff,P}$ and the d_P. In the case of gravity, $\beta_{0,E} = 1$ and $\beta 0, S = 2^{-11}$ and a good guess is that this is the case also for all planets [L121].

Note that the gravitational Compton length of the Earth is same for all particles and given by $\Lambda_{gr} = .5$ cm. One has for $E_E = 10^2$ V/m

$$\frac{\Lambda_{em,e}}{\Lambda_{gr}} \sim 6.1 \times 10^6 \ .$$

In the number theoretic sense, the electric body would be considerably smarter than the gravitational body.

10.4.3 The electrical Compton length of the Sun

In the Zoom session, Ville Saari made a question related to the Sun as an astrophysical quantum system, and I realized that although I had estimated the electric Planck constant h_{em} for the Sun. For the Earth one has $E_E = x \times 10^2$ V/m.

Consider first the electric Compton lengths for the Sun.

1. For the Earth one has $E_E = x \times 10^2$ V/m, $x \in [1,3]$. The value of the electric field at the surface of the Sun is $E_S = 1.5$ V/m: this gives $E_E/E_S = (x/1.5) \times 10^2$, $x \in [1,3]$.

2. For the electric Compton length $\Lambda_{ef}(d) = d$ of Sun one obtains from the scaling law

$$d_S = \frac{E_E}{E_S}\frac{\beta_0(S)}{\beta_0(E)} d_E \quad .$$

   This gives $d_S \simeq .033 d_E \simeq .3$ km for $E_E = 10^2$ V/m.

3. For the proton, the range of d_S would increase by a factor of $m_p/m_e \sim 2^{11}$ to about $[66, 198]$ km. Also this makes sense. Could the electric flux tubes relate to the solar wind? Not in any obvious way: the lower bound for the solar spot size is 1500 km.

One can also estimate the charge $Q_S(d_S)$ for the Sun. If one uses also in the case of the Sun the scaling law and the condition $d = \Lambda_{em}$ and assumes the same values of β_0 in the gravitational and electric case and that electrons are in question, one obtains the estimate

$$\frac{Q_S(d_S)}{Q_E(d_E)} = \frac{E_E}{E_S} \times \frac{\beta_0(S)}{\beta_0(E)} \quad .$$

This gives $Q_S(d_S)/Q_E(d_E) = .033$.

10.4.4 Electric Compton length for capacitor-like systems

To get some perspective and to test the idea it is useful to consider capacitors. In this case $\Lambda_{em}(d) = d$ should be smaller than the distance between the capacitor plates.

1. Aluminium capacitors can have a maximum charge of about $Q = 10^3$ C whereas the maximal charge of a van de Graaff generator is about .14 C. If one assumes $d = \Lambda_{em}(d)$, d_C is obtained by scaling as $d_C/d_E = E_E/E_C$. If the capacitor corresponds to a sphere of $D = 1$ mm with charge $Q = 10^3 C$, the electric field is $E_C = Q/4\pi\epsilon_0 D^2$ at the surface of capacitor and gives for $D = 1$ m $d_C = (E_E/E_C)d_E \sim 10^{-8}$ m for $E_E = 10^2$ V/m.

2. For a capacitor with capacitance of 1 μF and at voltage 1 V, the charge would be 1 μC. For $\beta_0 = 1$ would have the upper bound $\Lambda_{em,p}/\Lambda_{gr} \sim 2.9 \times 10^{-3}$ so that one would have $\Lambda_{em,p} \sim 1.5 \times 10^{-5}$ m. This gives an upper bound for the value of $\Lambda_{em,p}$ since the parameter d must correspond to a solid angle smaller than 4π. Could electronic systems be intelligent and conscious at least on this scale?

Neuronal axon is also a capacitor-like system and it is interesting to check what the criterion $\Lambda_{em}(d) = d$ gives in this case. The natural guess for d as quantum coherence length is as the length of the axon idealized as a cylindrical capacitor. Using $Q = E 2\pi R d$ and the condition $Q(d)e/\beta_0 = d$ one finds that the conditions does not depend on d at all so that it allows all lengths for axons, which is a very nice result from the point of neuroscience.

The condition however fixes the Compton length of the particle considered. Are there any chances of satisfying this condition for protons or electrons? The condition reads as

$$E \times 2\pi R\epsilon_0 \times (C/e)4\pi\alpha = \frac{1}{\lambda} \quad .$$

Here R is the radius of the axon taken to be $R = 1$ μm. Using $E = V/D$, where $D \simeq 10$ nm is the thickness of the neuronal membrane. and assuming $V = .05$ V, one obtains $E = 5 \times 10^6$ V/m.

For $\beta 0 = 1$, the estimate for λ_e is in a good approximation $\lambda_e = 10^{-12}$ m to be compared with the actual value $\lambda_e = 2.4 \times 10^{-12}$ m. The equation $d = \Lambda_{em}(d)$ is fixed apart from a numerical factor of order 1 so that the proposal seems to make sense.

If one assumes that Cooper pairs of electrons are the charged particles, one obtains $\lambda_{2e} = 1.2 \times 10^{-12}$ m. If one scales down D with a factor 1/2 to 5 nm, one obtains $\lambda_e = 1.2 \times 10^{-12}$ m, which could be true in absence of superconductivity. The thickness of the cell membrane indeed varies in these limits and is larger for neuronal membranes. One can wonder whether the dynamics is such that the quantity ER stays constant so that the condition remains true.

One can perform the same estimate for DNA strand having the 3 nucleotides per nanometer carrying unit charge. The condition $\Lambda_{em}(Qe)\hbar\lambda/\beta_0 = (dn/dl)\alpha \times 4\pi(d/beta_0) = d$ gives

$$\lambda = \frac{dn}{dl}\frac{\beta_0}{4\pi\alpha} \quad .$$

The condition is satisfied for electron if one assumes $\beta_0 \simeq 2^{-11}$: one obtains $\lambda = 1.5 \times 10^{-12}$ m to be compared with the actual value $\lambda_e = 2.42 \times 10^{-12}$ m. The Compton length for a Cooper pair would be 1 $\lambda_{2e} = 1.21 \times 10^{-12}$ m.

10.4.5 Could classical electromagnetic and gravitational fields give rise to collective consciousness in even historical time scales?

Paul Kirsch made an interesting question about whether the proposed gravitational and electric collective levels of consciousness assignable to Sun and planet could carry information about the history of biosphere and human kind. It is interesting to consider this question quantitatively by using the basic length and time scales predicted by TGD inspired quantum biology.

1. For the gravitational magnetic body of Earth the gravitational Compton length is $L_{gr,E} = GM/\beta_0 \simeq .5$ cm ($\beta_0 = 1$). For Sun one has $L_{gr,S} \sim R_E/2$ ($\beta_0 = 2^{-11}$ for the inner planets), R_E the radius of Earth. The corresponding time scales are rather short: .16 ns for the Earth and 10 μs for the Sun.

2. For the electric fields of Earth and Sun the values of "IQ" defined by the electric Planck constant $h_{eff} = \hbar_{em}$ can be considerably higher than for the corresponding gravitational fields. The condition $\Lambda_{cr}(d) = d$ for the radius of the flux tube as coherence region restricts however strongly the value of h_{em}.

   (a) The electric Compton length $L_{e,em}(d) = d$ for electron in the case of Earth corresponds to the range $9 - 27.5$ km assignable to the lightnings and the fact that the upper bound is roughly one half of the height of the ionosphere. This scale is only the lower bound for the transversal quantum coherence scales and one can argue that the flux tubes could be longer but shorter than the height of the ionosphere so that this scale could closely relate to the plasma life.

   If one does not pose the condition $\Lambda_{em} = d$, the electric Compton lengths for the Earth are much longer. For protons one obtains $\Lambda_{em,p} \simeq 10^3 R_E$. For electrons one has $\Lambda_{em,w} \simeq 2 \times 10^6 R_E$ to be compared with $AU \simeq 2.34 \times 10^4 R_E$, the distance of Earth from the Sun.

   (b) For the Sun, the electric Compton length for electron defined by $\Lambda_{e,em}(d) = d$ are rather short: .3 km for electron and 66 km for proton assuming $E_E = 10^2$ V/m in the scaling. If one gives up the condition $\Lambda_{em}(d) = d$, one has $\Lambda_{em}(S) = 2 \times 10^8 R_E$ to be compared with $A = 2.2 \times 10^4 R_E$.

   (c) For a pair formed by say charge Z and mass M and Sun, the electric Compton length and time are scaled up by a factor Zm_p/M from those of protons. This factor is in general smaller than one so that historical times scales cannot be obtained by increasing the charge.

The natural guess is that the electric and gravitational fields correspond to collective consciousness of some kind. Could it be the collective consciousness of the human kind or of the biosphere? Could our understanding of our physical environment rely on direct sensory experience of these collective levels of consciousness about their electromagnetic and gravitational bodies? Could our science based conscious information be represented on astrophysical scales so that the target of science could determine the scale of the corresponding cognitive representations?

Consider first the gravitational magnetic bodies.

1. For the Milky Way the mass is about $1.55 \times 10^{12} M_S$, the gravitational Compton length $L_{gr,MW}$ would be for $\beta_0 = 1$ about $L_{gr} \sim 1.55 \times 10^{12} \times \beta_0(Sun)$ km $\sim .8 \times 10^9$ km, which would give $T_{gr} \sim .8 \times 10^7$ seconds, which is rather near to year which is 3.2×10^7 seconds! For $\beta_0 = 1/4$ one would obtain a year.

2. To get historical time scales in the gravitational case, one should have a larger astrophysical object, perhaps a local galaxy cluster. Galaxy clusters have masses $10^2 - 10^3$ times the mass of the Milky Way. This would give a time scale of 100-1000 years, which is historical.

What about the electric Compton time for the Milky Way in the case of dark protons? Galaxy is estimated to have a Coulomb charge of about 10^{31} Coulombs. The radius of the Milky Way is 52,850 ly. Using the definition $\Lambda_{em}(d) = d$ and $\beta_0 = 1$ one would obtain $\Lambda_{em}(p) \simeq .42$ cm which happens to be rather near to the gravitational Compton length .5 cm for the Earth. For electrons one obtains $\Lambda_{em}(e) \simeq 2.1$ μ m, which corresponds to the size scale of the cell nucleus. Quite generally the condition $\Lambda_{em}(d) = d$ implies that Λ_{eff} is small and decreases with the size of the system.

10.5 How could Egyptian pyramids and rainmaking relate to each other?

I received from Zakaria Ahmindache a link to a very interesting article of Borisov published in Researchgate [I56](see this) with title "The Egyptian Pyramids-Connection to Rain and Nile flood Anomalies".

10.5.1 Background considerations

Since a topic involving words like ancient Egypt, pyramids and rainmaking probably induces strong emotional reactions in skeptics, it is good to include some TGD background and also make clear that the proposal of Borisov provides an excellent opportunity to develop the TGD based conceptualization of quantum biology by applying it.

A possible unification of various types of life and consciousness

I have taken a rather skeptic attitude to everything that involves ancient Egypt but at this time I felt fascinated. The reason was that during last weeks I have been working with a breakthrough in TGD inspired theory of consciousness and of living systems suggesting a unified view of different types of consciousness assignable to biosystems, plasmoids, quartz (possibly computers) and quite generally to any system, which involves cold plasmas and therefore ions [L122].

1. The key notion is what might be called OH-O^- qubit. The transition OH $\rightarrow$ O^- + dark proton at the gravitational magnetic body of the Sun or Earth flips this qubit-like entity. This transition occurs in the Pollack effect [I48, L16, I82, I66], which has become a key notion in the TGD inspired quantum biology [L94]. The reverse transition occurs when the electron of O^- is excited so that the difference of the bond energy of OH and binding energy of the electron changes sign. This effect might be called the dual Pollack effect.

   This transition generalizes. Any salt can decompose to ions and the positive ion could be assigned to the gravitational magnetic body of the Earth or Sun. Biosystems are full of ions of this kind.

2. The dark variant of the genetic code is one of the basic ideas of TGD and one can understand it in a very detailed manner if the qubits associated with the phosphates of the double DNA strand and phosphates and ribosomes of a single RNA strand provide a representation of the genetic code. In proteins COOH could assign a single qubit to each amino acid.

3. This also allows us to see alcohols (see this), involving -OH as a key structural element, in a new light. Pollack effect could induce a kind of elevated state of mind. Psychedelics (see this) involve -NH as a key structural element and Pollack effect inducing the transition NH $\rightarrow$ N^- + dark proton could be essential element of the psychedelic action.

4. The amazing finding is that in transistors the energy scales are the same, varying from about .5 eV (the metabolic energy quantum) to .15 eV (the energy of thermal photon at physiological temperature) as assigned to OH+O^- qubits. Therefore computers might under certain condition become conscious entities as speculated already earlier [L104, L103] and qubits could in the same relation to bits as dark qubits in information DNA and RNA to the bits of the genetic codons. This relation allows dynamics since only the minimum energy state of the codon corresponds to the chemical codon. Same would be true for computers. The gravitational magnetic body of Earth could receive information from the bit level and control it.

Zero energy ontology

Zero energy ontology is a key notion of TGD and TGD inspired theory of consciousness and solves the basic paradox of the quantum measurement theory.

1. ZEO predicts two kinds of state function reductions (SFRs): the "big" ones (BSFRs) and the "small" ones (SSFRs). The sequence of SSFRs means in standard quantum theory repeated measurements of the same observables and gives rise to conscious entities, selves.

2. BSFRs change the arrow of time and from the point of view of self this means death or falling asleep. ZEO predicts that roughly half of the Universe has an opposite arrow of time. This part of the Universe might be called a "kingdom of dead".

   Indeed, biological death changes the arrow of time in rather long scales and means reincarnation with an opposite arrow of time, eventually possibly followed by a reincarnation with an original arrow of time. Sleep is a temporary death in this sense.

10.5.2 A TGD inspired comment about the mythology of the ancient Egypt

The mythology of ancient Egypt has many analogies with the ontology of the TGD inspired view of consciousness.

1. The mythology of ancient Egypt suggests an interpretation in terms of zero energy ontology (ZEO). The "kingdom of dead" is non-observable using purely classical signalling since the signals from the other side propagate to the geometric past and do not reach us. Therefore we do not remember anything about the periods of deep sleep. The notion of ka fits nicely with this.

   "Big" quantum jumps (state function reductions, BSFRs) occurring in arbitrary long scales are predicted to be possible and rainmaking could involve such a pair of BSFRs and thus a visit to the "kingdom of dead" at some level of hierarchy. Trance of a shaman could be such a visit.

2. There is connection to the recent work involving OH-O^- qubit idea already described, possibly unifying plasmoid-, quartz -, computer-, and biological consciousness [L122]. I have discussed the possibility of computer consciousness from the TGD point of view also in [L104, L103].

10.5.3 A TGD inspired model for rainmaking

As the title "The Egyptian Pyramids-Connection to Rain and Nile flood Anomalies" suggests, the article suggests that pyramids had a deeper purpose: they could be used to induce rain. This sounds madness in the ears of a standard physicist but in 1895, Charles Wilson, a physicist, meteorologist, and Nobel Prize winner, made a groundbreaking discovery: he proved that rain could be artificially created. The rainmaking technology has also been commercialized.

The key idea in making rain is that a generation of the negative electric charge in the quartz contained by the soil leads to its accumulation to the atmosphere. The negative electric charge in the atmosphere in turn facilitates the formation of water droplets around them and eventually this induces rain. Could TGD explain this?

The model of Borisov

Consider first the proposal of the article of Borisov [**?**].

1. A deceased king, along with jars containing provisions for the afterlife, is placed inside a coffer, which is a hermetically sealed volume, The jars contain beer, bread, grain, ox, and sweets. The provisions within the jars undergo fermentation, where yeast converts the sugars present in food into carbon dioxide, water, or ethanol. This process can occur within a sealed coffer with no air intake, as long as the necessary conditions for yeast growth are provided. Some studies have found that fatty acids present in ox meat are essential for sustaining this growth.

2. The carbon dioxide generated by the process cannot escape and increases the pressure in the coffer of which 40 percent is quartz. The pressure in turn generates by piezoelectric effect (see this) an electric field generating negatively charged ions, which would move through the moist lime-stone core of the pyramid towards its apex and would be eventually emitted.

The TGD based interpretation of the model of Borisov

Consider the TGD interpretation of this model.

1. The transition OH $\rightarrow$ O^- + dark proton at gravitational magnetic body of the Earth (or Sun) occurs in quartz subject to electric field or under pressure in an electric field (piezoelectric effect transforming pressure gradient to electric field) and would generate negative ions.

2. In the case of a pyramid, the negative ions from quartz could flow to the tip of the pyramid and generate a high density of negative charge and strong electric field. From the tip the negative charges could flow to the atmosphere and serve as seats for the condensation of water droplets. Note that water is the key element of TGD inspired biology: Pollack effect [I48, L16, I82, I66] would generate negative charged exclusion zones and dark protons at the gravitational magnetic body.

3. The presence of electric fields changes the energy of the electron of O^- and by driving the difference of bonding energy and binding energy near the thermal energy, can make the system very sensitive to the transitions between the OH-O$-$ qubits. Quartz is a piezoelectet so that pressure gradients generate an electric field and have the same effect.

4. The TGD interpretation is that the electric fields increase the sensitivity of quartz to the generation of O^- ions plus dark protons at the gravitational monopole flux tubes. System would become to some extent living.

   Fermentation (see this) creates alcohols, which contain the characteristic -OH group (OH $\rightarrow$ O^- + dark proton).

   Does this process occur in the body of the king? Mummification means dehydration so that all moisture is removed so that the metabolism does not occur and the body does not decay. At the molecular level, dehydration reaction means that water molecules are removed from a molecule or ion. This can mean a removal of OH groups (see). The basic information molecules contain -OH groups and -NH groups. This would suggest that in the mummified body the analog of the Pollack effect producing O^- and N^- qubits is not possible.

5. Could some kind of collective consciousness assignable to quartz and water in the atmosphere wake up during rainmaking and induce the rain as a pair of macroscopic BSFRs? Ths would have no explanation in the framework of standard physics and in this sense would be literally a miracle, which we however experience every night and morning.

10.6 James Webb Space Telescope is also revolutionizing biology

JWST continues to make discoveries revolutionizing not only cosmology and astrophysics, but also the views about the evolution of life. The talk "Nobody Expected JWST To Find Signs of Oceans on Makemake and Eris + More From Kuiper Belt" of Anton Petrov (see this) told about the newest findings related to the Kuiper belt and about surprising findings related to the dwarf planets Eris and Makemake.

10.6.1 Second Kuiper belt?

Consider first the discoveries related to the Kuiper belt made by satellite New Horizons. The Kuiper belt seems to be either much thicker than thought or that there are actually two of them. According to the findings of New Horizons satellite, the latter option looks more plausible. The candidate for a new Kuiper belt consists of a very dense dust. Solar wind could have blown the dust from the inner Kuiper belt to this region but this explanation is not very plausible.

TGD view of the formation of astrophysical objects [L109, L110] suggests the possibility of belt like structures and even spherical layers. The empirical findings suggesting that ionosphere involves plasmoids as primitive non-biological life forms suggests the symbiosis of biomolecules associated with the dust particles with plasmoids led to the development of primordial life forms [L100].

What came as a surprise to me was that the Kuiper belt is the most colored object in the solar system. The explanation would be the presence of organic molecules emitting light at visible frequencies. This also explains the reddish color of the belt. Also Pluto and many dwarf planets have turned out to have relatively young surface layers with an organic chemistry involving highly complex organic molecules, in particular molecules with ring structures. This suggests that the chemical life developed at the outskirts of the solar system and then moved inwards.

10.6.2 Dwarf planets are not we expected them to be

JWST provided information suggesting that Eris and Makemake have oceans and complex surface chemistry. This makes them candidates for the seats of primordial chemical life. Orcus, Pluto, Haumea, Quaoar, and Makemake are dwarf planets in the Kuiper belt extending from the distance 30 AU of Neptune to the distance of 50 AU. Also some solar system's moons such as Neptune's Triton and Saturn's Phoebe might have originated in the Kuiper belt. Even the Moon could have emerged by a collision of an object possibly coming from Kuiper belts with Earth. Eris, at a distance of 68 AU and Makemake at a distance of 46 AU are examples of dwarf planets located outside the Kuiper belts.

In a sharp conflict with expectations, Pluto, dwarf planets and many moons are very active and involve a complex organic chemistry giving them their reddish colors. For instance, Pluto is very active. It possesses a thin exosphere and 5 moons creating tidal effects, which also can provide metabolic energy. JWT has now managed to provide information of elements present at the surface of Eris and Makemake and even isotope ratios D/H and C13/C12 at the surface of Eris and Makemake. This allows us to conclude that the surface is very young. An interesting question is how the active surface structure has emerged. Also evidence for geochemical processes, solid state convection, and subsurface oceans have been found. These oceans seem to resemble Enceladus, which is a moon of Saturn regarded as a strong candidate for simple exterrestrial life. All that is needed by life on the Earth, including oceans, seems to be present.

Object	M/M_E	R/R_E	$\Lambda_{gr}/\mu m$	e_{gr}/eV
Earth	1	1	5e+03	2.48e-03
Pluto	.00218	0.18	10.9	0.11
Eris	.0028	.182	14.0	.09
Ceres	1.57e-04	.07	0.79	1.58
Enceladus	1.8e-05	.04	.09	13.8
Titan	0.023	.4	115.0	0.01
Ganymede	.025	.413	125.0	.001
Moon	.0123	.2727	61.5	.02

Table 10.1: The table gives for Earth, Pluto, some dwarf planets, and some moons of the solar system, their masses M and radii R using Earth mass M_E and radius R_E as units. Also gravitational Compton lengths $\Lambda_{gr} = \hbar_{gr}/m = r_s/2\beta_0$ for $\beta_0 = 1$ and corresponding energies $E = h/\Lambda_{gr}$ (h is ordinary Planck constant) are given.

10.6.3 The TGD view of the findings

In the TGD view of life, the TGD counterparts of both gravitational and electromagnetic fields, differing many aspects from their Maxwellian counterparts, have a fundamental role, in particular the long range electric and magnetic fields of both Sun, Earth, and other planets would are important [L100]. The electric body of Earth provides electric fields in the ionosphere, which is in many respects analogous to the cell membrane.

One of the very first predictions of TGD was that any body with gravitational mass must have electric charge although it can be arbitrarily weak. The negative electric charge generating electric fields can be generated by the Pollack effect transforming protons of ordinary matter to dark protons at the magnetic bodies of various objects [L100]. Dark particles have an effective Planck constant which can be much larger than ordinary Planck constant.Darkness in this sense explains the missing baryonic matter and plays a key role in TGD based biology. Galactic dark matter in turn can correspond to what colleagues call dark energy and would be associated with long cosmic strings, whose thickening to monopole flux tubes is the TGD counterpart for the decay of the inflaton field generating ordinary matter.

Negative charges are a basic aspect of living systems: DNA, cell, and Earth itself are basic examples. The delicacy is that the charge separation generated in this way is between the biological body and magnetic body rather than the system and its environment in the ordinary sense. Charge separation is like loading of a battery and requires energy. The formation of biomolecules as bound states of simpler constituents could provide the energy needed by this process. Water and the formation of silicates would be essential ingredients. Also galactic cosmic rays could have served as a source of this energy in Kuiper belts.

In the TGD based model for terrestrial life the role of quantum is central. The gravitational Planck constant $\hbar_{gr} = GMm\beta_0$ introduced by Nottale defines gravitational Compton length $\Lambda_{gr} = \hbar_{gr}/m = r_s/2\beta_0$, $r_s = 2GM$ as a fundamental scale to which one can assign gravitational Compton frequency $f_{gr} = 1/\lambda_{gr}$ and gravitational Compton energy $e_{gr} = h/f_{gr}$ as biologically interesting parameters. The following table gives these parameters for $\beta_0 \simeq 1$ assignable to the magnetic body of Earth and possibly also for other planets, their moons and dwarf planets. For the system formed by the Sun and inner planets one would have $\beta_0 \simeq 2^{-11}$. For the system formed by the Sun and outer planets one would have $\beta_0 \simeq 2^{-11}/5$. The following table gives these parameters for $\beta_0 \simeq 1$ assignable to the magnetic body of Earth. Scaling gives the values of these parameters assignable to the magnetic body of the system formed by the object and Sun.

Note that for Earth the gravitational Compton energy is 2.48 meV. For the Earth the gravitational Compton frequency, possibly associated with a fundamental biological rhythm, is especially high. For the Earth the Λ_{gr} is for solar gravitational magnetic body with $\beta_0 \simeq 2^{-11}$ equal to $R_E/2$ and corresponds to $f_{gr} = 50$ Hz which is EEG frequency. For Mars $\beta_0 \simeq 2^{-11}/5$ one has $\Lambda_{gr} \simeq R_E/4 \sim R_{Mars}/2$ and the gravitational Compton frequency $f_{gr} \sim 100$ Hz is at the top of EEG spectrum. In a good approximation, one obtains from the table estimates for Λ_{gr} and

e_{gr} by the replacement $eV \to .1\ meV$ and $\mu m \to 1\ cm$

10.6.4 Scent of space

Heikki Hirvonen sent a link to a FB post about the scent of space (see this). He is the content of the FB post.

"Astronauts say that space smells like gunpowder and burnt steak. It being a vacuum and all, space isn't often thought of as having a scent of its own. And while no one has directly smelled outer space, exposure without a helmet would be fatal. Many astronauts have reported that it smells like a mix of gunpowder and burnt steak. The odor is most noticeable after an astronaut returns to their spacecraft through the airlock and removes their helmet, at which point the lingering scent can be detected by both the astronaut who had been outside the ship and their crewmates who remained aboard.

It has been theorized that the source of space's scent is dying stars, which release molecules called polycyclic aromatic hydrocarbons, a chemical compound also found in coal, oil, and food as they near the end of their existence.

There's even a cologne named Eau de Space based on the smell, which was originally synthesized by biochemist Steve Pearce at NASA's behest to better prepare astronauts for every aspect of the job. Based on his interviews with astronauts who had been to space, Pearce described the aroma as hot metal, burnt meat, burnt cakes, spent gunpowder, and welding of metal."

PAHs (polycyclic aromatic compounds) look like a possible explanation. They would produce IR radiation assigned with unidentified infrared bands (UIBs) and since the odour sensation at the fundamental level is based on IR light, UIBs could produce the sensation.

Consider first PAHs. I have considered PAHs several times while developing TGD view of quantum biology.

1. PAHs are obtained by fusing together organic molecules involving aromatic rings and are produced in burning and are often poisonous. The list of the basic properties of PAHs [I2, I12] (see `http://tinyurl.com/atx4t9a`) can be found for instance in [L42].

   The properties of PAHs have led to the PAH world hypothesis stating that PAHs are predecessors of the recent basic organic molecules. For instance, the distances of aromatic molecules appearing as basic building bricks are the same as distances of DNA base pairs.

2. So called Unidentified Infrared Bands (UIBs) of radiation around IR energies $E \in \{.11, .20, .375\}$ eV arriving from the interstellar space are proposed to be produced by PAHs. The UIBs can be mimicked in the laboratory in reactions associated with photosynthesis producing PAHs [I2, I12].

3. PAHs are detected in interstellar space. James Webb telescope found that PAHs exist in the very early cosmology 1 billion years before they should be possible in the standard cosmology! Furthermore, PAHs exist in regions, where there are no stars and no star formation [**?**].

   The interpretation of the findings in the TGD framework is discussed in [L119] [K103]!

1. In the TGD framework, a possible explanation would be that the nuclei involved are not produced by hot fusion in stars but by dark fusion occurring at rather low temperatures. PAH world as a predecessor of recent chemical life would have developed in interstellar space.

2. The original TGD inspired proposal was that dark fusion preceded "cold fusion" associated with prestellar objects preceded ordinary nuclear and ignited hot fusion leading to the formation of the stellar core [L109]. The numerous anomalies related to the standard model of the Sun assuming that the energy is produced in the core of the Sun suggest that something in the nuclear physics of the Sun is badly misunderstood. The analysis of the anomalies in the TGD framework leads to a rather radical proposal assuming that also the interior of the Sun is at a rather low temperature and dark fusion prevails in this region. The core would be a quantum system analogous to the cell interior or even cell nucleus [L123]. Needless to say this would completely change our views about the Sun and of life and consciousness.

Sun would be in a well-defined sense a living system needing metabolic energy feed. Solar surface would contain a layer producing both solar wind and solar energy and would receive metabolic energy feed from outside, for instance from galactic black holes along monopole flux tubes. This view requires taking seriously the prediction of TGD that ordinary hadron physics is accompanied by several scaled variants of hadron physics. In particular, M_{89} hadron physics with a mass scale which is 512 times higher than for ordinary hadron physics [L123]. The transformation of M_{89} nuclei to ordinary nuclei would produce solar energy and also provide the Sun itself with metabolic energy.

3. In the TGD framework, this picture suggests that PAHs might have been created as an outcome of dark fusion in interstellar space. PAHs might have made possible a primitive form of metabolism and photosynthesis [K11, K106] at relatively low temperatures prevailing in interstellar space. This would have made it possible for plasmoids as primitive life forms to store metabolic energy chemically. The hypothesis about plasmoids as predecessors of the recent chemical life forms in the Earth's ionosphere is discussed in [L100].

4. Dark proton sequences, providing a universal representation of the genetic code, based on a completely unique hyperbolic tessellation known as icosa tetrahedral tessellation [L98], would have realized the genetic code for the plasmoids and the chemical code would have emerged later. Also the recent realization of the genetic code would involve sequences of dark protons, with genetic codons represented as dark protons triplets. The triplets of dark cyclotron photons forming quantal units would induce resonant transitions between the dark codons: 3-resonance would be in question. Genes with N codons would give rise to 3N-resonances and a universal addressing in the communications by dark 3N-photons with the message coded to frequency scale modulation.

This does not yet say anything about how PAHs and UIBs could relate to the scent of space.

1. Luca Turin (see this) discovered that the absorption of infrared light produces odour perception. The earlier view was that a purely chemical mechanism involving the attachment of odorant molecules to the odour receptors is the mechanism of the odour perception. At the basic level the odour sensation would be however produced by infrared light. In particular, space odout might be produced by the infrared light emitted by PAHs. This makes possible remote odour perception.

2. In principle, also the solar radiation at infrared wavelengths could induce the sensation of odour. The odorant molecules could be present in the air inside the helmet. They would be excited by UIB light arriving from interstellar space and emit IR photons as they return to the ground state. This would generate the sensation of the scent of space. In the long run sensory adaptation would lead to the situation in which the scent of space is not perceived anymore. When the astronaut is outside the aircraft sensory adaptation takes care that the sensation is not felt. The sensation is most intense when the helmet is removed after the return to the spacecraft.

Whether the UIBs are produced by ordinary chemical transitions associated with photosynthesis or its predecessor or whether they involve new physics suggested by TGD, is an interesting question to ponder.

1. This relates interestingly also to the Pollack effect, which is most effectively induced by infrared light. Pollack effect is indeed central in the TGD inspired quantum biology and is a non-chemical transition in which photons provide the energy kicking protons to the "magnetic body" of the molecule. It is also essential in photosynthesis and in a temporary non-chemical storage of metabolic energy to the magnetic body of the system.

   In the Pollack effect and its TGD inspired generalizations, the photon would increase the value of effective Planck constant h_{eff} for the protons. This could make the Compton length of the radiation, emitted as a dark photon as the proton transforms to ordinary proton, very long.

2. Could the large value of h_{eff} make possible space scent even without the presence of PAHs in the nearby environment? Smell is usually regarded as a sense restricted to rather short scales. Basically it would be infrared vision. Could this make it possible to smell over astrophysical distances?!

   In fact, insects are known to be able to smell over distances measured in tens of kilometers. Could the real reason be that the smell sensation is also now mediated by (dark) infrared photons rather than by diffusing odorant molecules? I learned from my chemist friend that the odour of vanilla cannot be produced artificially. Could one understand this in terms of dark IR photons?

Chapter 11

TGD Inspired Model for Nerve Pulse

11.1 Introduction

The model of nerve pulse has developed through several tortuous twists reflecting the development of the basic ideas of TGD inspired theory of consciousness and of bio-systems as macroscopic quantum systems, and is certainly not final yet. The chapters about EEG provide a necessary background for the model of nerve pulse. The chapter [K81] was written before dark matter revolution made possible a more detailed modelling of mew physics aspects of EEG. The newer chapter [K38] related to EEG provides a very general vision about the hierarchy of EEGs based on dark matter hierarchy and about its possible generalization to ZEG, WEG, and even GEB (Z, W and G denote for dark Z^0, W boson, and gluon fields with interaction range which can be arbitrary long at higher levels of dark matter hierarchy). This model derives from the model of bio-superconductivity [K76, K77] as quantum critical high T_c super-conductivity [K18, K19]. The consistency with the model of DNA as topological quantum computer [K2] poses additional strong constraints on the model. The findings of Gerald Pollack about fourth phase of water [L16] lead to additional strong constraints on the model of cell membrane as Josephson junction.

The basic hypothesis has been that quantum jump takes the resting potential below the threshold for the generation of nerve pulse. One can imagine several way for how this could happen.

1. The first idea was that axonal membrane acts as a Josephson junction and that a soliton propagating along it induces the nerve pulse. The model for the high T_c electronic superconductivity allowed to construct a detailed model for this Josephson junction and "time-like" and possibly also space-like soliton sequences are indeed present. Time-like soliton sequences however represent oscillations at a frequency of order 10^{13} Hz. It is however clear that moving solitons cannot correspond to nerve pulses.

   Quite recently (2014), strong motivations for generalizing the notion of Josephson junction so that Josephson energy includes also the difference of cyclotron energies at the two sides of the junction has emerged. It is also possible to reduce cell membrane as Josephson junction to a collection of Josephson junctions defined by various transmembrane proteins such as pumps and channels.

2. The strange findings about ionic membrane currents discussed in [K76, K77] challenge the assumption cell membrane could be described in term of known biochemistry alone. Pollack's experiments [L16] demonstrate the existence of what he calls the fourth phase of water. This phase contains negatively charged regions - exclusion zones - serving in TGD Universe as candidates for prebiotic cells. The positive charge resides outside the exclusion region at the flux tubes of the magnetic body associated with the exclusion zones as dark proton strings defining dark nuclei realizing vertebrate genetic code [K49]. This vision leads to a generalization of the model of cell membrane Josephson junctions assignable to transmembrane proteins. Josephson energy becomes sum of Coulombic term and difference of cyclotron energies at the

two sides of the membrane. The thermodynamical model for cell membrane is replaced with its "square root" forced by Zero Energy Ontology, and means the replacement of Boltzmann weights with their square roots appearing in the wave functions for dark particles. The phase transitions changing Planck constant change the equilibrium distributions of ions and this process should be behind the generation of nerve pulse.

3. There exists also evidence that nerve pulse propagation is be an adiabatic process [?, ?, ?, ?, ?] (thanks to Ulla Mattfolk) 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. If h_{eff} changing phase transition changing the equilibrium ionic concentrations occurs, the phase transition in question should not absorb or liberate heat. Combining this input with the model of DNA as topological quantum computer (TQC) [K2] leads to a rather precise model for the generation of nerve pulse.

11.1.1 The Most Recent Model For The Generation Of Nerve Pulse

Quite recently I learned [?, ?, ?, ?, ?] (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) [K2] 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 solitonic 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. At microscopic level nerve pulse could correspond to a phase transition changing the value of Planck constant h_{eff} at the either side or both sides of the cell membrane at the flux tube associated with the transmembrane protein. This would induce transition to a new ionic equilibrium since cyclotron energies for ions change. This transition would give rise to the change of the membrane potential. Cyclotron energy difference would however dominate in the generalized Josephson energy. This phase transition should be adiabatic and should not require heat or generate it.

4. 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.

5. New physics would enter in several way. Ions should form Bose-Einstein cyclotron condensates. The new nuclear physics predicted by TGD [L4]. [L4] predicts that ordinary fermionic ions (such as K^+, Na^+, Cl^-) have bosonic chemical equivalents with slightly differing mass number. 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. Clearly, the temperature at dark magnetic flux tubes could be lower than the physiological temperature. The model for the role of DC currents and potentials in healing discussed in [K11] suggests that metabolic energy quanta of order 1 meV are involved in bio-control so that the temperature at magnetic flux tubes containing ions could be by a factor of order 10^{-2} lower than the physiological temperature. 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 ways to achieve this if new nuclear physics is indeed present.

11.1.2 The Function Of Neural Transmitters

TGD leads to a general view about the functions of membrane oscillations, nerve pulse and neural transmitters. Electromagnetic membrane oscillations induced by Z^0 MEs provide a realization of the memetic code as a fundamental cognitive code. The binding of various information molecules to the corresponding receptors gives rise to neuronal qualia analogous to tastes and odors but providing information about external world whereas ordinary receptors give information about nearby environment. At our level of hierarchy these qualia probably correspond to emotions in consistency with the finding that neurotransmitters can be identified as information molecules. Neurotransmitters might be also seen as conscious links in quantum web. The view that inhibition actually requires active energy feed and that excitation occurs automatically in the absence of the energy feed and induces entanglement with environment, is defended. This view conforms with Huxley's vision about brain as a filter inhibiting conscious experiences.

11.1.3 What Happens At The Micro-Tubular Level During Nerve Pulse?

What happens at the micro-tubular level during the nerve pulse? How gel phase differs from sol phase? What occurs in sol-gel transition? These questions represent some of the principal challenges faced by quantum theories of consciousness.

There are two candidates for Bose-Einstein (BE) condensates associated with the ordered phases (say gel) of water. This derives from the fact that the zero point kinetic energy of hydrogen atom at space-time sheet k is in a good approximation same as the zero point kinetic energy of an electronic Cooper pair at space-time sheet $k + 10$ (see the article "Time, Space-time, and Consciousness" in [L2]). Thus both the BE condensates of hydrogen atoms at tubular $k = 139$ space-time sheets forming bundles behaving like liquid crystals and BE condensates of electronic Cooper pairs at $k = 149$ space-time sheets forming linear structures could accompany gel phase and ordered water phases. Positive and negative energy IR photons at energy of $\sim .125$ eV belong to the predicted fractal hierarchy of metabolic currencies, and allow to control the stability of this BE condensate so that a precisely targeted control of the cellular state by local sol-gel transitions becomes possible. Albrecht-Buehler [I46] has demonstrated that photons with energy $E \sim .1$ eV have a maximal effect on cells.

The seesaw mechanism discussed in the article "Quantum model of sensory receptor" of [L2] minimizes dissipative losses and allows to understand how micro-tubular surfaces could provide dynamical records for the cellular sol-gel transitions, and thus define a fundamental micro-tubular representation of declarative long term memories.

As far as nerve pulse is considered, one ends up with the proposal that the soliton propagating along axon might be a shadow of a more fundamental soliton propagating along microtubular surface and inducing gel-sol-gel transition meaning disassembly and reassembly of tubulins which induces a braiding of magnetic flux tubes coding the details of the sensory signal below millisecond time scale to the braiding pattern.

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` [L14].

11.2 Background For The Model Of Nerve Pulse

The following sections give some background for the model of nerve pulse.

11.2.1 General Vision About Living Matter As A Macroscopic Quantum System

The following assumptions summarize the general vision achieved before the dark matter revolution. The picture is consistent with the findings of Libet about strange time delays of consciousness [**?**, **?**] discussed in the article "Time, Space-time and Consciousness" in [L2] and chapter [**?**].

1. Magnetic bodies forming a hierarchy are the fundamental volitional agents transforming intentions to actions. Intentions are represented by p-adic MEs transformed to negative energy MEs representing the desire about particular activity communicated to the lower level magnetic bodies in the geometric past and eventually to the material body. Each negative energy ME in the cascade represents a desire to realize some submodule in motor program. Eventually the cascade of negative energy MEs ends up to the glial cells serving as metabolic sources. The desired action is generated in terms of neural communications and of positive energy MEs both representing classical communications to the geometric future. The desire in question could be a desire to perform a particular motor action, a desire to direct attention or select among sensory percepts (binocular rivalry is the standard example), or a desire to remember something. Sensory perception, motor action, and memory would thus be based on essentially the same basic mechanism. The population inverted many-sheeted laser system providing the energy source in brain or body would consist of bosonic ions or of Cooper pairs of fermonic ions in excited cyclotron states.

2. Sensory representations are realized at the magnetic bodies associated with the sensory organs and sensory mental images are shared with the personal magnetic body by negative energy em MEs. Brain constructs only symbolic and cognitive representations, writes the sensory music to notes. The mental images defined by these representations can be shared by personal magnetic body or magnetic bodies associated with the sensory organs in a similar manner. Also classical communications to the personal magnetic body are possible. A tree like structure with the root represented by sensory mental images and branches and leaves represented by various symbolic and cognitive mental images results.

   The selective entanglement by negative energy MEs allows to understand the active aspects of sensory experience involving direction of attention and selection between percepts at various levels. In the case of motor actions, the negative energy MEs received from magnetic body communicate the desires of the magnetic bodies about motor actions to be performed and the response by positive energy MEs would realize these desires as nerve pulse patterns.

3. Positive energy interior MEs lie along interior of magnetic flux tubes of the personal magnetic body. These MEs could relate to the classical communication of the symbolic representations constructed from the data processed in the brain to the magnetic body. Sensory perception and memory differ only is that the time scale involved is different. Declarative memory

corresponds to negative energy MEs sent from a point of the personal magnetic body at the distance $L = cT$ to the material body and reflected back as positive energy MEs. Thus the material body serves as the mirror unlike in the original variant of the mirror mechanism of memory. The distance $L = cT$ along magnetic flux proportional to the transverse area S of the flux tube $L \propto S$ tubes codes for the temporal distance to the geometric past by transforming it to cyclotron frequency scale.

11.2.2 A General View About Quantum Control, Coordination And Communication Inspired By Dark Matter Hierarchy

The following general overview about quantum communication and control emerges from the model for EEG hierarchy as correlate for dark matter hierarchy discussed in detail in [K38].

1. Cyclotron frequencies relate to the control of the biological body by the magnetic body and could be assigned with the magnetic flux sheets going through DNA since it is genome where protein synthesis is initiated and is thus the optimal intermediate step in the cellular control.

2. One of the basic functions of cell membranes is to perceive the chemical environment using various kinds of receptors as sensors. Neurons have specialized to receive symbolic representations of the sensory data of primary sensory organs about the situation in the external world. A good guess is that in this case magnetic flux quanta are hollow cylindrical structures serving as templates for axons and possibly other similar structures and define the communication lines connecting cell membranes to the magnetic body.

3. This picture would explain why the temperature of brain must be in the narrow range 36-37 K to guarantee optimal functionality of the organism. If interior superconductivity is lost, magnetic body receives sensory data but is paralyzed since its desires cannot be realized. If boundary superconductivity is lost, magnetic body can move but is blind.

4. In the length scales below the weak length scale L_w also charged weak bosons behave as massless particles and the exchange of virtual W bosons makes possible a non-local charge transfer. Dark quark-antiquark pairs associated with the color bonds of the atomic nuclei can become charged via the emission of dark W boson and thus produce and exotic ion. The same can happen at the higher levels of dark matter hierarchy.

5. Massless extremals (MEs, topological light rays) serve as correlates for coherent states and Bose-Einstein condensates of dark bosons. Besides neutral massless extremals (MEs) TGD predicts also charged massless extremals obtained from their neutral counterparts by a mere color rotation (color and weak quantum numbers are not totally independent in TGD framework). The second non-local quantum control mechanism is based on em charge entanglement involving a superposition of ordinary ions/atoms and exotic ions connected by a W massless extremal joining magnetic body and biological body. In quantum jump this state would be reduced to exotic charge state with some probability increasing with the strength of the classical W field. Charged massless extremals could be seen as correlates for non-local quantum control by affecting charge equilibria whereas neutral MEs would serve as correlates for coordination and communication. Color charged MEs could also induce color charge polarization and flows of color charges and thus generate visual color qualia by the capacitor mechanism discussed in [K45].

6. It has become clear that the most plausible model for nerve pulse generation is as a phase transition changing the value of h_{eff} at the flux tube portion at either or both sides of the cell membrane. In the modification of the thermodynamical model of cell membrane based on "square root" of thermodynamics forced by ZEO, this would induce a change of ionic equilibrium distributions and generation of nerve pulse.

7. These non-local quantal mechanisms can induce or change electromagnetic polarization in turn inducing ordinary charge flows and thus making possible quantum control of nervous system by magnetic body. The generation of nerve pulse could rely on the spontaneous state function reduction occurring for charge entangled state reducing the resting potential below

the critical value by this kind of mechanism inducing charge transfer between cell interior and exterior. Also remote mental interactions, in particular telekinesis, might rely on this mechanism.

11.2.3 The Role Of Electronic Super-Conductivity

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. This isolation might of course be present and make possible ionic super-conductivity. 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 Coulomb interaction with the quarks and antiquarks associated with the throats of the wormhole contacts.

A crucial element is quantum criticality predicting that new kind of superconductivity, "boundary superconductivity", appears at the fluctuating boundaries of competing ordinary and large $\hbar$ phases for nuclei besides large $\hbar$ variant of ordinary superconductivity in the interior. The Cooper pairs of interior and boundary supra currents are different with interior Cooper pairs being BCS type. 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 c flux tubes and sheets are especially interesting candidates for dark supra current carriers and might define Josephson junctions. In this case the Cooper pairs must have spin one and this is indeed possible for wormholy 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 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 possibly proton Cooper pairs are possible at room temperature. The effects of ELF em fields on vertebrates suggest that Bose-Einstein condensates of all bosonic ions and their exotic counterparts resulting when some nuclear color bonds become charged [L4], [L4] are there but the model of high T_c super-conductivity does not favor them. It is of course possible that the temperature at dark magnetic space-time sheets is lower than at the visible space-time sheets.

Bose-Einstein condensates at magnetic flux quanta in astrophysical length scales

The new model for the topological condensation at magnetic flux quanta of endogenous magnetic field $B = .2$ Gauss is based on the dark matter hierarchy with levels characterized by the values of $\hbar r \hbar_0$ of Planck constant.

1. 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 scaled up electron Compton lengths $L_e(k) = \sqrt{5}L(k)$ 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 [K38]. 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.

2. There are several levels of dynamics. In topological condensation the internal dynamics of ions is unaffected and $\hbar$ has the ordinary value. The formation of Cooper pairs involves dynamics at lowest levels of dark matter hierarchy. Also the dynamics of ionic Cooper pairs remains unaffected in the topological condensation to magnetic flux quanta obeying dark dynamics with large value of Planck constant.

3. Cyclotron energies scale as as $r = 2^{k_d}$ so that for a sufficiently high value of k_d thermal stability of cyclotron states at room temperature is achieved. Spin interaction energy $\mu \cdot B \propto S \cdot B$ scales as $1/\hbar$ since four-momentum and angular momentum are by Poincare symmetry invariant under the scaling of $\hbar$ (the highly non-trivial implications of the invariance of angular momentum are discussed in [K111]). Hence spin interaction energy has the ordinary value. Unless thermal isolation is assumed, spin degrees of freedom are thermalized, and only cyclotron degrees of freedom can be quantum coherent. This is a testable prediction distinguishing between the new and old model.

4. If the flux quanta of $B = .2$ Gauss correspond to $k_d = 44$ level of dark matter hierarchy, cyclotron energies $E = (\hbar/2\pi) \times ZeB/Am_p$ are scaled up by a factor $2^{k_d} \simeq 2^{44}$ from their ordinary values and are above thermal energy at room temperature for $A \leq 233Z$, where Z is the charge of the ion. Even for $Z = 1$ this includes all stable nuclei. Bose-Einstein condensates of bosonic ions are thus possible at room temperatures at Earth's surface.

Experimental evidence for bio-superconductivity

From the beginning it has been obvious that super-conductivity serves some important function in nerve pulse conduction. For instance, Josephson currents are optimal for quantal alarm clocks [K81]. Already before the ideas inspired by the dark matter hierarchy the contact by Hafedh Abdelmelek and his group [**?**] led to a crucial step of progress in the understanding of this function. It became clear that genuine or effective electronic super-conductivity (in the sense that Cooper pairs are dropped temporarily to larger space-time sheets implying dissipation) is most probably involved with the propagation of the nerve signal through the myelin sheathed portions of the axon [K77].

The resulting simple model explained the experimental findings at quantitative level correctly and makes several predictions. In particular, one can understand why physiological temperature can have only a rather restricted range. The breaking of the electronic super-conductivity is an essential aspect of the ordinary nerve pulse conduction in this model. Also the distinction between poikilotherms (such as frog) and endotherms (such as rabbit) can be understood. As it often happens, the most recent model is not consistent with this model but is preferred by its simplicity.

Strange findings about cell membrane

There are very strange findings challenging the notions of ionic pumps and channels [I47, I52, I78, I31], and suggesting a mechanism dramatically reducing the metabolic costs involved with the ionic pumping. Second finding is that ionic currents seem to be quantal and are same for polymer membrane than for cell membrane! A further strange finding [**?**] is that the propagation of nerve pulse does not cause heating of the cell membrane implied by the model of nerve pulse based on chemistry. This suggests that dissipation is absent also during nerve pulse propagation and that the process might not be chemical as assumed hitherto.

One can imagine two explanations.

1. The first explanation would be that ionic currents are actually dark supra currents flowing along larger space-time sheet connecting cell interior and exterior. The model of high T_c super conductivity favors only electronic and protonic super conductivity at room temperature [K18] whereas the model for EEG favors the presence of Bose-Einstein condensates of ions. Bosonic ions are required: the new nuclear physics predicted by TGD [L4], [L4] allows to assign to fermionic ions their bosonic chemical equivalents. Even permanent connections with the cell exterior (by magnetic flux tubes, say) are possible since Josephson currents oscillate. One can of course consider the possibility that dissipation rate is small due to the large value of Planck constant even in the absence of super conductivity. Also the temperature could be lower at the magnetic flux tubes containing dark ions but this assumption will not be made.

2. Second model that one can imagine relies on the exotic nuclear physics predicted by nuclear string model [L4] , [L4] and the predicted hierarchy of fractally scaled up variants of weak interaction physics. If weak interactions can be present in cell length scales, the exchange of virtual or real $W^{\pm}$ bosons between nuclei could induce purely quantal and non-dissipative charge transfer between cell interior and exterior. Also charge entanglement becomes possible. The emission of $W^{\pm}$ would modify the nucleus to an exotic charged state in which one of the neutral color bonds connecting nucleons is charged. Since W exchange does not depend on cell membrane at all, the prediction would indeed be that ionic currents do not depend at all on the membrane in question. The model of nerve pulse however suggests that W exchange can have only a role of a control signal.

One can argue that pumps in case of basic ions are needed only when the cell interior and exterior are connected by join along boundaries bonds/flux tubes and that this connection is built only for diagnostic purposes in order to measure the concentrations of ions by measuring the ionic currents by their dissipation. The remote metabolism made possible by many-sheeted lasers reduces further the energy costs when pumping actually occurs. The transfer as Josephson current might apply only to the biologically important ions and pumps might be needed to achieve more efficient transfer also in this case. Pumps (active transport) and channels (passive transport) for more complex polar molecules realized as genetically coded proteins are certainly needed.

11.2.4 The Role Of MEs And Magnetic Flux Tube Circuitry

The developments in the understanding of the role of MEs and magnetic flux tube circuitry have repeatedly forced to rethink the model of nerve pulse and EEG.

Universe as a conscious hologram

1. The notion of conscious hologram means that Universe is an extremely complex fractal Feynman diagram with lines replaced by 4-dimensional space-time sheets and MEs are particular kinds of lines analogous to photon lines. These lines are like laser beams, which interfere in the vertices of the Feynman diagram: vertices correspond to material space-time sheets, atoms, molecules, ..., cells, ... Super-conducting magnetic flux tubes are also important and act effectively as wave guides along which MEs propagate.

2. Topological field quantization allows to assign to any material system a field (magnetic) body. The view that "me" corresponds to the personal magnetic body of an astrophysical size receiving information from the material body by both classical communications and by sharing of the mental images realized in terms of bound state entanglement having negative energy MEs as a space-time correlate, has become a key hypothesis in the attempts to understand the functions of nerve pulse and EEG. The idea about brain as the sole seat of consciousness is deeply rooted in scientific thinking, and it took some time before I was able to take really seriously the idea about magnetic body as an intentional agent controlling the material body serving as its sensory and motor organ. In this respect the latest developments occurred while writing this article.

3. MEs, in particular, the topological field quanta of ELF fields are in a crucial role as far as the understanding of EEG (and the predicted ZEG and WEG) is involved. After dark matter revolution it became clear that MEs are the natural correlates for coherent states and Bose-Einstein condensates of dark matter bosons. It is still an open question whether ordinary laser light might be regarded as a special case of dark photons. Certainly the transformation of dark bosons to ordinary ones would occur through a de-coherence phase transition just like the transformation of laser light to ordinary photons.

Various kinds of MEs

One can imagine many kinds of MEs.

1. Interior MEs correspond to what might be called ELF MEs but they form only a small portion of the spectrum of MEs characterized by the fundamental frequencies defined by their lengths $f = c/L$ extended to ULF frequencies which correspond to length scales of order light lifetime. Also MEs in time scales at least down to 10^{14} Hz corresponding to visible photons are predicted be important.

2. Also boundary MEs identified as MEs attached to the boundaries of matter carrying space-time sheet and drifting along it quantum jump by quantum jump by a velocity $v < c$ can be considered and MEs of this kind were in a key role in the previous model for nerve pulse generation. In the case of boundary MEs, which are assumed to be positive energy MEs, the effective phase velocity satisfies $v << c$, and from $f = v/L$ the sizes of the structures associated with a given frequency are smaller by a factor v/c.

3. Negative energy MEs, which correspond to phase conjugate laser light, make possible intentional action at the micro-tubular level, they are crucial for the understanding of the macro-temporal quantum coherence, and have also inspired the notions of remote metabolism and quantum credit card. The newest discovery along this line is what might be called seesaw mechanism of energy metabolism (see the article "Time, Space-time and Consciousness" in [L2]). Phase conjugate laser beams [D3, D2] seem to be the standard physics counterpart of negative energy em MEs and negative energy photons accompanying them.

4. Fractality implies that MEs contain MEs within MEs: this conforms with the general ideas about dark matter hierarchy and p-adic length scale hierarchy. MEs within MEs is the topological correlate for de-coherence of Fourier components of classical field. In the simplest situation MEs appear as pairs of high frequency and low frequency MEs. The scaling law of homeopathy [I16] states that low frequencies are accompanied by high frequencies such that the frequency ratio has preferred predictable values identifiable as characteristic velocities in the system (such as EEG phase velocity): $f_{low}/f_{high} = v/c$. The most general assumption about the spectrum of high frequency MEs inside low energy MEs is that it is scale invariant in the sense that the intensity satisfies $I(f_{high}, f_{low}) = I(f_{high}/f_{low})$.

   Low frequency negative energy MEs could serve as correlates for remote quantum entanglement in cyclotron degrees of freedom. W MEs would make possible charged entanglement. High frequency MEs travel effectively like massless particles along the bridges defined by the low frequency MEs and can transform to boundary MEs serving as bridges between different space-time sheets at the receiving end, in which case their effective phase velocity is reduced to $v << c$. These MEs could induce a leakage of ions between different space-time sheets, breaking of super-conductivity and dissipative self-organization. This process which is analogous to the formation of hologram, is responsible for homeostasis and metabolism and gives rise to many-sheeted ionic flow equilibrium. Also many-sheeted lasers acting in a very wide range of frequencies become possible. The frequencies correspond to differences for the energies of ions at the space-time sheets involved. MEs parallel to axons can also act as Josephson junctions connecting space-time sheets which can correspond to different p-adic primes.

The strange effects of ELF em fields on vertebrates as a key to the model for hierarchy of EEGs

The experimental findings of the pioneers of bio-electromagnetism [**?**] demonstrate that electromagnetic radiation at the harmonics of cyclotron frequencies of various ions in magnetic field $B = .2$ Gauss, in particular Ca^{+2} ion, are somehow involved with the bio-control. The dropping of ions from smaller space-time sheets to the super-conducting magnetic flux tubes of B indeed generates cyclotron radiation. The generalization of this [I21] [L1] explains the findings of Gariaev [I27] about radio waves induced by laser irradiation of DNA. The detailed model explaining various aspects of these findings on basis of TGD inspired model of high T_c superconductivity led to a detailed model for the hierarchy of EEGs (or EWEGS, with EW for electro-weak) generated by Josephson junctions as Josephson and by cyclotron transitions of Bose-Einstein condensates of bosonic ions.

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.

11.3 TGD Based Model For The Generation Of Nerve Pulse

The general vision about living system as a conscious hologram and the view about how "topological light rays" (massless extremals, MEs) serve as remote entanglers and induce self-organization via the leakage of ionic currents between various space-time sheets implies that several space-time sheet pairs are involved with the bio-control. Perhaps the most radical deviation from the standard neuroscience thinking came with the realization that in TGD Universe every physical system has also magnetic/field body of size much larger than the material body and that material bodies can be seen as motor and sensor organs of the personal magnetic body. This counter intuitive conclusion is unavoidable if one accepts many-sheeted macroscopic quantum coherence, Uncertainty Principle and topological field quantization. p-Adic physics as physics of intention and cognition provides an additional support for this view: the smaller the space-time sheet is p-adically, the larger it is in the real sense so that cognition and intentionality are predicted to be astrophysical phenomena and evolve from long to short length and time scales just as it indeed occurs when motor activity is learned.

The TGD based view about dark matter hierarchy involving a hierarchy of values of Planck constant provides a justification for this picture. Dark matter hierarchy corresponds to the hierarchy of moments of consciousness with increasingly long duration with respect to geometric time and defines a hierarchy of conscious entities and reflective levels of consciousness.

Dark matter hierarchy provides a mechanism for the formation of macroscopic and macro-temporal quantum phases in all length scales. The earlier assumption about thermal isolation of space-time sheets corresponding to different p-adic length scales can be given up and thermal stability condition becomes an additional strong constraint allowing to eliminate various options very effectively. Since cyclotron energies scale like $\hbar$, thermal stability is possible to achieve for them.

The quantum model of nerve pulse requires answer to several questions. Some of them are following.

1. Are various charged currents quantal or ohmic currents? For electrons and even protons an attractive answer is that they are quantal currents. The effects of ELF em fields on vertebrate brain suggest that also ionic currents are quantal and that Cooper pairs of ions might be involved. Hodkin-Huxley model assumes ohmic currents but the observations about cell membrane do not support this view.

2. If the ionic currents are quantal, are they oscillating Josephson currents or direct currents? For the direct quantal currents a model was constructed in previous section. If the thickness of Josephson junction is not much larger than Compton length then all Josephson currents in

cell membrane length require non-standard value of Planck constant. For electron it would be about 2^{11} and for proton about 2^{22} using the standard value of $\hbar$ as unit. For ions even large Planck constant would be required (its value scales like mass). The hierarchy of preferred values of Planck constant given by powers $m_p/me \simeq 2^{11}$ is suggestive. DNa as TQC suggests that also quarks are involved in this case the low masses would suggest Josephson currents.

3. Already the visible cell membrane is a highly structured object and many-sheetedness of space-time could play a key role. This could mean the presence of magnetic flux tubes with many values of Planck constant. Magnetic flux tubes would be natural models for the ionic channels and pumps. Note that DNA as TQC model involves flux tubes connecting DNA nucleotides and lipids. One can quite well consider the presence of both Josephson currents and direct quantal currents except perhaps for electron Cooper pairs and possibly they protonic counter parts.

4. In the case of fermionic Cooper pairs one can consider Cooper pairs as building bricks of Bose-Einstein condensate. Also exotic nuclei which are bosons but chemically equivalent with fermionic ions can be considered. The argument of previous section favors Cooper pair option and direct ionic currents.

5. One can consider two kinds of basic extremals. Near vacuum extremals for which classical Z^0 fields are important and far from vacuum extremals for which they are small. The latter extremals would correspond naturally magnetic flux tubes carrying monopole Kähler magnetic flux. Both of them might be involved with the ionic channels and pumps. As extreme situations one can consider two models of cell membrane assuming only near to or far from vacuum extremals.

6. What is the mechanism generating the nerve pulse? This mechanism should change the stationary situation in which only oscillatory Josephson currents are present and generation of quantal direct current is suggestive. Does this current consist of electron Cooper pairs or possibly ions of their Cooper pairs? Is there a primary wave - say Ca^{++} wave - involved. Why de-polarization instabilizes the situation? As found in previous section, the model for ionic direct currents suggest a possible explanation for this.

In this section TGD based model of nerve pulse and EEG inspired by the soliton model of Danish researchers and the model of Pollack is discussed. Also a model for the action of anesthetics is proposed.

11.3.1 Soliton Model Of Nerve Pulse

Let us first briefly summarize soliton model of nerve pulse proposed by Danish researchers [**?**, **?**, **?**, **?**].

1. The temperature of the axon is slightly above the critical temperature T_c for the phase transition leading from crystal like state of the lipid layers to a liquid crystal state. Near criticality the elastic constants and heat capacity of the membrane vary strongly and have maxima at criticality so that also sound velocity varies strongly near criticality. Also the relaxation times are long. There is also dispersion present meaning that the frequency of sound wave depends nonlinearly on wave vector. Non-linearity and dispersion are prerequisites for the presence of solitons which by definition do not dissipate energy.

2. Variations of temperature, volume, area, and thickness and also other mechanical effects are known to accompany nerve pulse propagation. It is also known that the heat density and temperature of the cell membrane increases slightly first and is then reduced. This suggests adiabaticity in average sense. These findings motivate the assumption that nerve pulse actually corresponds to acoustic soliton [**?**, **?**].

3. Soliton model reproduces correctly the velocity of nerve pulse inside myelin sheaths but it is not clear to me how well the much lower conduction velocity in non-myelin sheathed regions is reproduced. It is not clear how the lower values of the conduction velocity and its

proportionality to the axonal radius in non-myelinated regions can be understood. Intuitively it however seems clear that the lower velocity is due to the feedback from the interaction of ions with the region exterior to cell membrane. In the case of myelin sheaths the conduction of nerve pulse is usually believed to take place via saltation [**?**]: the de-polarization induced at Ranvier node is believed to be enough to take the membrane potential below critical value in the next node so that nerve pulse hops between the nodes. Insulation would improve the insulation and make this process possible. The reversible heat transfer process is however known to be present also in the myelinated portions of axon so that there must be a pulse propagating also in these regions [**?**]. It is not clear how the myelin sheet can increase the velocity in the soliton model but the reduction of the feedback inducing friction suggests itself.

4. Soliton property predicts adiabaticity. Ordinary ionic currents however dissipate so that adiabaticity assumption is questionable in standard physics context. The model does not predict the growth of entropy followed by its reduction. This behavior is consistent with adiabaticity in a time resolution of order millisecond.

5. The estimate for the capacitor energy density during the nerve pulse is considerably smaller than the energy density is many times magnitude smaller than that of the acoustic wave. This might allow to demonstrate that Hodgkin-Huxley model is not a complete description of the situation.

6. Authors notice [**?**, **?**] that the shapes curves representing solitonic energy density and the capacitor energy density as a function of time are essentially identical. Same applies to the experimentally deduced heat change release curve and capacitor energy density for garfish axon. Also heat release and the deviation of the membrane potential from its resting value are in exact phase. These similarities could reflect a control signal responsible for the nerve pulse originating somewhere else, perhaps at micro-tubules. This could explain why secondary nerve pulse is not generated immediately after the first one although the temperature is slightly lower after the pulse than before it. This could of course be also due to the exhaustion of the metabolic resources.

11.3.2 TGD Based Model Of Nerve Pulse Assuming Far From Vacuum Extremals

The model of nerve pulse described below can be motivated by the observed adiabaticity of the nerve pulse and by the strange findings about ionic currents associated with the cell membrane and by the model of Danish researchers for the nerve pulse [**?**, **?**, **?**, **?**]. The model involves also a fusion of various ideas of earlier models. In particular, Josephson currents and solitons are in a key role in the model but with the necessary flexibility brought in by the hierarchy of Planck constants. The model of nerve pulse by Pollack [I47] discussed at the end of previous section allows to understand the behavior of ionic currents quantitatively. In this subsection a model of nerve pulse based on the assumption that cell membrane represents far from vacuum extremals so that classical Z^0 field is very small will be discussed. In subsequent subsections the model for which cell membrane is almost vacuum extremal will be developed with main motivation coming from the observation that the model predicts correctly the frequencies of peak sensitivity for the four photoreceptors.

Consistency with the absence of dissipative currents through the axonal membrane

The basic inputs of the TGD based model are following.

1. The presence of acoustic soliton or density pulse proposed by Danish researchers [**?**] looks plausible but a a more fundamental quantum control mechanism inducing the acoustic soliton cannot be excluded. Among other things this should explain why acoustic solitons propagate always in the same direction. In particular, one can consider a soliton like excitation (say breather for Sine-Gordon equation) associated with the electronic or ionic Josephson currents running along magnetic flux tubes. The strange effects associated with the ionic currents

through the cell membrane suggest quite generally that at least weak ionic currents through normal cell membrane are non-dissipative quantal currents. The adiabaticity of the nerve pulse suggests that also strong ionic currents are quantal. This suggests identification as either Josephson currents or direct quantal currents discussed in previous section. In stationary situation direct currents would vanish by boundary conditions whereas Josephson currents would be oscillating. Direct currents as generator of nerve pulse would allow to understand why de-polarization induces nerve pulse.

2. Strong ionic currents generating nerve pulse through axonal membrane are absent in the resting state. The naïve explanation is simple: the life time of the magnetic flux tubes connecting the axonal interior to the exterior is short or the flux tubes are altogether absent. The observation that Josephson currents in constant voltage are automatically periodic suggests a less naïve explanation allowing the flux tubes to be present all the time. The presence of ionic Josephson currents predicts a small amplitude oscillation of membrane potential for which 1 kHz synchronous oscillation is a natural identification. Josephson oscillation correspond naturally to propagating soliton sequences for Sine-Gordon equation. The dynamics of the simplest modes is equivalent to the rotational motion of gravitational pendulum: the oscillation of membrane potential corresponds to the variation of $d\Phi/dt \propto V$. Note that if axon is above the melting temperature, the lipid layer is in gel phase and fluid motion is impossible. The surface density of lipids is dramatically reduced at criticality so that lipid layers behave like fluids [**?**]. This means that TQC is not possible by the braiding of lipids.

3. Nerve pulse is generated when the magnitude of the negative membrane potential is reduced below the critical value. Generation of the nerve pulse is like a kick to a rotating gravitational pendulum changing the sign of $\Omega = d\Phi/dt$ so that rotational motion is transformed to oscillatory motion lasting for about the period of rotation. An opposite but slightly stronger kick must reduce the situation to the original one but with a slightly higher value of Ω. These kicks could correspond to voltage pulse between micro-tubules and inner lipid layer of cell membrane induced by the addition of small positive (negative) charge on lipid layer. This pulse would induce electronic DC Josephson current inducing the kick and thus reducing V. For instance, the exchange of scaled variants of W bosons (assignable to W MEs) could mediate the transfer of charge through the cell membrane and reduce the membrane potential below the critical value but one can consider also other mechanisms. Another possibility is generation of direct ionic currents of Ca^{++} and Cooper pairs of Na^{+} ions. This in turn could be induced by a perturbation of electronic (and perhaps protonic) Josephson current. The analog for the stationary situation is a sequence rotating penduli with constant phase difference along axonal membrane. Nerve pulse corresponds to a propagation along the axon of a wave in which some penduli oscillate rather than rotate.

4. The conservative option would be that ordinary ionic currents take care of the rest and Hogkin-Huxley model applies. This was assumed in the earliest model in which soliton sequence for Josephson current was assumed to induce nerve pulse sequence: in the recent model this assumption does not make sense. The findings of Danish researchers do not however support the conservative option [**?**] . Nerve pulse could be due to dark ionic (possibly supra -) currents with large $\hbar$ with a low dissipation rate. Their flow would be made possible by the presence of magnetic flux tubes connecting cell interior and exterior.

The relationship with the model of Pollack

In the model of Pollack [I47] for the action potential gel-sol-gel phase transition for the peripheral cytoskeleton accompanies the generation of the action potential. The model allows to understand reasonably well the behavior and the physical role of the ionic currents and explains various anomalies. Using pendulum analogy, the kick to the rotating pendulum representing Josephson junction would force it to an oscillatory motion inducing a gel-sol-gel phase transition propagating along the peripheral cytoskeleton.

The challenge is to understand how quantum criticality making possible the phase transition is induced.

1. The primary Josephson currents from the micro-tubuli to the axonal membrane would reduce the magnitude of the cell potential below the critical value (slowing down of the pendulum rotation). This should somehow take the peripheral cytoskeleton near to quantum criticality and induce the increase of Planck constant for the flux tubes connecting peripheral cytoskeleton to the axonal membrane and increasing their length so that they would extend to axonal exterior. This would make possible the flow of Cooper pairs of monovalent dark ions (say Na^+) from the axonal exterior replacing Ca^{+2} acting as cross links between negatively charged proteins and in this manner induce gel-sol phase transition. The reverse phase transition would reduce Planck constant. If ionic currents are non-dissipative they flow back automatically much like oscillating Josephson currents.

2. Gel-sol phase transition can be compared to melting since in the gel phase the hydrogen bonds induce effective freezing of various globular proteins to their folded configuration and naturally unfolded proteins to their unfolded configurations. This melting quite generally induces protein aggregation. Melting requires energy to destroy the hydrogen bonds and during action potential the system receives this energy somehow. One could even imagine that action potential generates both positive energy Josephson radiation inducing melting and phase conjugate Josephson radiation inducing freezing again and that these two steps correspond to an increase of Planck constant and its reduction back to the original value. Josephson radiation could quite generally control biological functions by inducing protein aggregation.

3. There are two forms of quantum criticality corresponding to critical sub-manifolds $M^2 \times CP_2$ and $M^4 \times S^2$, where $M^2 \subset M^4$ has interpretation as plane of non-physical polarizations and $S^2 \subset CP_2$ is a homologically trivial geodesic sphere of CP_2 with vanishing induced Kähler form (see the Appendix of [K2]). The latter kind of quantum criticality corresponds to very weak induced Kähler fields and thus to almost vacuum extremals. Given electromagnetic field can be imbedded as a 4-surface in many ways: as a vacuum extremal, as a surface maximizing Kähler electric energy, or something between them.

4. Quantum criticality suggests that em fields in the cell interior correspond to non-vanishing but not too large induced Kähler fields in the resting state. The magnitude of the cell potential in the absence of the membrane is about -50 mV and slightly below the magnitude of the critical potential of -55 mV [I47]. Hence the reduction of the magnitude of the em (-or more precisely- Kähler-) voltage between the inner boundary of the peripheral cytoskeleton and cell exterior to a small enough value could induce almost vacuum extremal property and quantum criticality making $\hbar$ increasing phase transition for the magnetic flux tubes connecting peripheral cytoskeleton to the axonal membrane possible. This framework would also allow to understand the paradoxical fact that a reduction of the magnitude of the cell potential induces the action potential rather than its increase as the naïve idea about dielectric breakdown would suggest.

5. Action potential should induce gel-to-sol phase transition somehow and Josephson radiation generated during the action potential could be responsible for this. During action potential the energy of Josephson covers a wide range so that it could couple to metabolic energy quanta. If the frequency of Josephson radiation is considerably higher than the rate of variation of the action potential the situation is adiabatic in the sense that the energy of Josephson radiation is effectively constant. The situation is optimal during the maximum +40 mV of the action potential. Josephson radiation could couple resonantly to the gel defined by the peripheral cytoskeleton and induce fast transfer of protons from large to small space-time sheets and generate metabolic energy quanta helping to destroying the hydrogen bonds. This should somehow induce the increase of Planck constant for the magnetic flux tubes responsible for the gel-to-sol phase transition. This admittedly speculative and somewhat misty idea has been discussed already earlier and will reconsidered in the section where the relationship of the model with microtubular level is discussed.

6. The value of the membrane potential is -55 meV at criticality for the generation of the action potential and +40 meV at the maximum [J1]. All the values between them could correspond to energies of Josephson radiation, which for certain values of membrane potential correspond

to metabolic energy quanta. The range of variation for membrane voltage allows all Josephson energies down to cutoff energy for which the frequency of Josephson radiation is of same order than the rate of relative variation of the membrane potential. Explicitly this condition reads as

$$\frac{\frac{dV}{dt}}{V} \ll \frac{f_0}{r}\frac{V}{V_0} \quad , \quad r = \frac{\hbar}{\hbar_0} \quad .$$

Here f_0 is the the Josephson frequency for $r = 1$ and for the resting potential V_0 and is of order 10^{14} Hz for almost vacuum extremals and 10^{13} Hz for far from vacuum extremals. Josephson frequency must be considerably above kHz frequency defined by the duration of the action potential. Therefore Josephson radiations below *resp.* above kHz frequency must relate to resting state *resp.* action potential and must correspond to different biological functions. For $r = 2^{k_d}$ the kHz frequency correspond roughly to $k_d = 36$ for almost vacuum extremals and to $k_d = 33$ for far from vacua. Note that the p-adic length scale determined by the wave length of Josephson radiation for $k_d = 36$ is 16 cm - the size scale scale of brain.

7. There are two options depending on whether the cell membrane is assumed to correspond to almost vacuum extremal or not.

   (a) For far from vacuum extremal option the energies of Josephson photons in the case of proton are 55 meV and 40 meV for the mentioned values of membrane potential and corresponds to IR radiation. The Josephson energies in case of proton and electron are by an order of magnitude smaller than the nominal energy.5 eV for standard metabolic energy quantum. The metabolic energy quantum liberated in the dropping of proton Cooper pair from $k = 139$ atomic space-time sheet or of electron Cooper pair from $k = 151$ cell membrane space-time sheet to a much larger space-time sheet is $\simeq .62$ eV for the nominal value of.5 eV for the dropping of proton from $k = 137$ space-time sheet to much larger space-time sheet. Note however that $E = E_0(1 - 2^{-k})$ spectrum for metabolic energy quanta gives energy $E = 47$ meV for $k = 2$. One can criticize this option because one must assume non-standard metabolic energy quanta and there must be a separate control mechanism inducing their generation.

   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.

   (b) The cutoff frequency is certainly considerably higher than kHz. For almost vacuum extremal the Josephson energy is

$$E = Q_{eff}(p)e \times V \quad , \quad Q_{eff}(p) = 3 - \tfrac{1}{2p} \quad , \quad p = sin^2(\theta_W) = .029 \quad .$$

   One has $E = .7$ eV for V=-55 mV and $E = .56$ eV for V=+40 meV. The latter value is not too far from the nominal value.5 eV for the basic metabolic energy quantum. Note that during nerve pulse Josephson radiation in a wide range of energies is emitted. Besides this there is energy spectrum associated with ions. The energies for $(Na^+.Cl^-, K^+, Ca^{+2})$ are (2.2, 2.74, 3.07, 2.31) eV for -55 mV and (1.60, 2.00, 2.23, 1.68) eV for +40 mV (Table 3). Note that at maximum of V 2.00 eV metabolic energy quantum is associated with Cl^-.

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

(11.3.1)

Table 11.1: The modification of cyclotron frequencies of most important ions are modified by simplest replacements with exotic ions

What the replacement of Ohmic ionic currents with quantal currents means?

Before the replacement of Hodgkin-Huxley model with a genuinely quantal model can be taken seriously, one must answer many difficult questions which also Hodgkin and Huxley must have faced as they developed their own model. It is best to proceed by making questions and answers.

Q: In the resting state membrane potential is negative and cell has a negative net charge. What stabilizes the cell against the leakage of the negative charge if pumps and channels are not responsible for this?

A: The findings about the strange behavior of cell membrane inspire TGD based answer. Cell membrane space-time sheet is its own quantum world and the flow of ions occurs only in the presence of magnetic flux tubes connecting it to the external world. These currents a however oscillatory Josephson currents if dissipation is absent. Hence there is no need to cut completely the connections to the external world.

Q: How the resting state can result spontaneously if pumps are absent?

A: If ionic currents are Josephson currents, they are automatically oscillating and the return to the original state is guaranteed. The flux tubes carrying the ionic currents will be assumed to connect axonal micro-tubules to the space-time sheet of the cell interior. Consider first the most obvious objections.

1. Dark ions cannot transform to ordinary ones in the exterior of the cell membrane. This might indeed kill the model.

2. The second objection is that all biologically important ions are not bosons and the model for high T_c super-conductor in its recent form allows only electronic and protonic Cooper pairs at room temperature [K18]. TGD based nuclear physics however 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.

Table 11.1 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^{+2}_- 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 $f(Ca^{+2})/2 = 7.5$ Hz, $f_c(Mg^{+2}) = 12.5$ Hz, and $f(Ca^{+2}) = 15$ 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.

For small oscillations the maximal charge transfer ΔQ generated by an oscillating ionic Josephson current during the cycle is proportional to $\hbar/f_J \propto \hbar^2$ and $\hbar/\Omega \propto \hbar$ for solitonic situation. ΔQ is very small for the ordinary value of $\hbar$: also the oscillation period is very small. For large values of $\hbar$ situation changes and large maximal ion transfers are possible. An $\hbar$ increasing phase transition could be involved with the generation of the nerve pulse. Quantum criticality during nerve pulse generation indeed suggest the presence of flux tubes with varying values of $\hbar$. The

lifetimes of the connected flux tubes could be proportional to $\hbar$ at criticality. A fractal hierarchy of pulses and EEG like oscillations of the membrane potential corresponding to various values of $\hbar$ is suggestive.

Q: Can one make this more quantitative?

A: One can construct a model based on Sine-Gordon wave equation for the phase difference Φ between the superconductors connected by Josephson junction sequences defined by magnetic flux tubes and idealizable as a continuous Josephson junction.

1. For a Josephson junction idealizable as a hollow cylinder with radius R and thickness d the expression of the Josephson current reads as

$$J = J_0 sin(Ze \int V dt/\hbar) \ .$$

J_0 is in case of cell membrane given by

$$J_0 = \frac{Ze2\pi dR}{\Lambda^2}\frac{\hbar}{m} \ ,$$

where R and d would be now the radius and thickness of the axon, Λ is the magnetic peneration length, and m is the mass of the charge carrier. Although this expression does not hold true as such when Josephson junctions are replaced by magnetic flux tubes connecting micro-tubules and axon, one can can safely make some qualitative conclusions. The amplitude of the Josephson current increases with $\hbar$. For electron the value of the amplitude is by a factor $x \simeq Am_p/m_e \simeq 2^{11}A$ larger than for ion with a mass number A. This gives for electron Cooper pairs a unique role as an initiator of the nerve pulse. Note that the amplitudes of the Josephson currents of electron and ions are quite near to each other if one has $\hbar(ion) = 2^{11}A\hbar e$.

2. Electronic Josephson current dominates and makes it ideal for the generation of nerve pulse (kick to gravitational pendulum). This is possible if the net amount of electronic charge is so small that it flows out during the generation of flux tubes. For ions this need not occur even if ion densities are of same order of magnitude. Constant voltage V creates an oscillating current and no catastrophic leakage takes place and the resting state results automatically. The ionic Josephson currents assignable to the magnetic flux tubes connecting micro-tubules through the cell membrane to the external world could be responsible for the nerve pulse.

3. The mechanical analog for Sine-Gordon system [B3] assignable to Josephson junction is rotating pendulum but one must be cautious in applying this analogy. There are two options concerning the modelling of the situation.

   (a) Membrane potential represents an external voltage $V(t)$ and one has $\Phi_i = Z_i e \int V dt/\hbar$, where Φ is the phase difference between Bose-Einstein condensates.

   (b) System is autonomous and membrane potential $V(t) = \hbar(d\Phi_i/dt)/Z_i e$ is completely determined by the dynamics of any phase Φ_i. This option is highly predictive and discussed in the sequel.

4. The analogy with gravitational pendulum allows to identify the phase angle Φ as the counterpart of angle Θ characterizing angular position of mathematical pendulum (note that this analogy can be misleading since it implicitly brings in 3-D thinking).

   (a) In this picture rotating pendulum corresponds to a soliton sequence containing infinite number of solitons: both stationary and moving soliton sequences are obtained. The sign of $\Omega = d\Phi/dt$ is fixed and approximately constant for large values of Ω. Resting potential could correspond to this kind of situation and $\Omega \simeq 2\pi$ kHz is suggested by kHz synchrony. A mechanism of this synchrony will be discussed below. For large

values of $\hbar$ even values of Ω in EEG range could correspond to membrane potential. For large values of Ω one as $V \simeq \hbar\Omega_i/Z_i e$. If also EEG rhythms correspond to Ω they must correspond to different values of $\hbar$ and $f \propto 1/\hbar$ would hold true. Changes in the dominating EEG rhythm (40 Hz, 10 Hz, 5 Hz, ..) could correspond to phase transitions changing $\hbar$ to given value for a large number of axons. The maximal charge transfer during single period is proportional to $\Delta Q \propto 1/\Omega$.

(b) Hyper-polarization/depolarization would mean fastening/slowing down of the pendulum rotation and slowing down would make the system unstable. Near criticality against the generation of nerve pulse would mean that pendulum is rotating rather slowly ($\Omega \ll f_J$) so that a small kick can transform rotation to oscillation. The sign of $V \propto d\Phi/dt$ would change and large amplitude oscillatory motion would result for single period only after which a kick in opposite direction would lead back to the resting state. Membrane potential varies between the resting potential $V_0 = -75$ mV and $V_1 = +40$ mV during nerve pulse: $V_1 > |V_0|$ would have killed the model. Note that $V_1 = 40$ mV is rather near to the critical potential about $V_1 = 50$ mV: ideally these potentials should be identical.

(c) The so called breathers -both stationary and moving- correspond to soliton-antisoliton bound state (see the visualization in [B3]). Breathers could be identified as large amplitude oscillations around $\Phi = 0$ ground state. Physical intuition suggests that breathers are possible also for a ground state corresponding to a rotating pendulum (representing moving or stationary waves). They would correspond to kicking of one pendulum in a sequence of penduli along z-axis rotating in phase at the initial moment. The kick could correspond to a genuine external perturbation generated by a pair electronic supra current pulses of opposite sign giving constant velocity increments $\Delta\Omega$ initiating and halting the nerve pulse just like they would do in the case of TQC but in opposite time order. If the background corresponds to a propagating EEG wave, also nerve pulse is expected to propagate with same velocity. The propagation direction of EEG wave would also explain why nerve pulses propagate only in single direction.

5. For the ordinary value of $\hbar$, the frequency Ω of the Josephson current corresponds to that assignable to energy.07 eV being around $f = 1.6 \times 10^{13}$ Hz and quite high. One can look at the situation in light of $r \equiv \hbar/\hbar_0 = 2^{11k}$ hypothesis, which has however turned out to be quite too restrictive. For $r \equiv \hbar/\hbar_0 = 2^{44}$ the frequency would be near to cyclotron frequency of about 1 Hz assignable to DNA strands. For $x = 3 \times 2^{3\times 13}$ f would be near to the fundamental 10 Hz frequency which is secondary p-adic time scale associated with electron and correspond to the temporal duration of negative energy space-time sheet assignable to electron. For $r = 3 \times 2^{3\times 11}$ one would obtain a 640 Hz frequency which corresponds to the time scale of nerve pulse. It seems clear that the original hypothesis that only powers of 2^{11} define the spectrum of Planck constant is too restrictive and Mersenne hypothesis introduced in the introduction seems more plausible hypothesis although even this hypothesis is too too restrictive [K38]. The requirement that cyclotron frequencies and Josephson frequencies are proportional to each other for small oscillations would guarantee resonant behavior for common strength of the magnetic field would give $\hbar \propto A$. This would require that each ion species lives at its own flux tubes.

6. The realization that cell membrane could correspond to almost vacuum extremal [K38] changed the situation completely. For vacuum extremals Z^0 and em fields are proportional and if one assumes that almost vacuum extremals define a phase in which the Z^0 charges of quarks are fed to almost vacuum extremal unlike electrons, one must replace ionic charges with effective charges proportional to the nuclear charge. This raises the energy scale defined by the resting potential to visible and UV range.Note that also neutral atoms are Z^0 ions in this phase. Otherwise the model for cell membrane as Josephson junction remains the same. This hypothesis can be defended by its success: it predicts correctly the values of frequencies of maximum sensitivity for photoreceptors in terms of Josephson energies of various ions and almost vacuum extremal property conforms also with the quantum criticality of living matter. This model will be be discussed in detail in the sequel.

Q: What instabilizes the axon? Why the reduction rather than increase of the magnitude of the membrane potential induces the instability? Why the reduction of the resting potential below the critical value induces nerve pulse?

A: Large enough voltage pulse between micro-tubules and membrane could generate electronic DC supra current. The introduction of a small amount of positive charge to the inner lipid layer and staying there for some time would generate the voltage pulse between micro-tubules and lipid layer so that DC electronic supra current would be induced, and induce the reduction $\Delta V \simeq .02$ eV of the magnitude of the membrane potential. A similar introduction of negative charge would induce hyper-polarization and the direction of the current would be opposite if it is generated at all. The proposed model for direct current explains why de-polarization induces instability. Ionic direct quantum currents could thus be the generators of nerve pulse as in Hodkin-Huxley model and Ca^{++} ions and Na^{+} Cooper pairs are in preferred position. The mechanism generating the small positive charge to the inner lipid layer could be based on the exchange of exotic W bosons between pairs of exotic nuclei at opposite sides of the cell membrane so that the negative charge of the inner lipid layer would be reduced.

Q: Can one understand the observed radial force, the increase of the radius of axons and the reduction of its thickness, and heating followed by cooling?

A: The observed outward force acting on a test system might be due to quantum currents. Josephson currents are oscillatory and are not expected to cause any force. Ionic direct currents could induce the force. The pressure caused by the ionic direct current pulse might relate to the increase of the radius of the axonal membrane and with the reduction of its thickness as well as the slight increase of its temperature as being due to the ions which heat the lipid layer as they collide with it and are transferred to smaller space-time sheets if they energy is large enough.

1. This hypothesis combined with the model for direct quantal currents allows to express the momentum flux as product of ionic particle current $n_I v = n_I p/m$ and momentum of charged current carrier equal to $p = \sqrt{2mE_n}$ at the plate of the analog of capacitor. This gives the estimate for the contribution of given bosonic ion or Cooper pair of fermionic ions to the force f per unit area as

$$\begin{aligned} f_I &= n_I \times 2E_n \ , \ , \\ E_n &= sin(2\delta)(\frac{nqE\hbar}{r\sqrt{m}})^{2/3} \ , \ r == \frac{2}{3} \ , \\ \Psi &= Rcos(U+\delta)exp(-iE_n t) \ . \end{aligned} \tag{11.3.2}$$

The representation of Ψ was introduced in previous section. Here δ parametrizes the current, which vanishes for $\delta = 0, \pi/2$. This gives

$$f_I(t) = n_I \times (\frac{nqE\hbar}{r\sqrt{m_I}})^{2/3} \ , \ r = \frac{2}{3} \ . \tag{11.3.3}$$

The force is proportional to $E^{2/3}$ rather than $E = V/d$ (electric field). There is proportionality to $m^{-1/3}$ so that lightest charges give the dominating contribution if their densities are small for some reason.

2. The force caused by ionic Josephson currents on a small piston of area S parallel to the membrane is given by

$$F = \sum_I n_I \times (\frac{nqE\hbar}{r\sqrt{m_I}})^{2/3} S \ . \tag{11.3.4}$$

The comparison with the observed force gives estimate for the densities n_I of ions at the flux tubes.

3. According to [**?**] in one particular experiment the force on piston of area $S = .01$ cm^2 at the maximum of voltage is $F = 2$ nN. This gives for proton mass the rough estimate $n_I \sim 2/L_e(151)^3$, where $L_e(151) = 10$ nm is the p-adic length scale defining cell membrane thickness. For heavier ions large densities of super-conducting ions or their pairs would be required. Perhaps the simplest option is that the direct current pulse of dark proton Cooper pairs induces the force whereas the Josephson currents of electrons give rise to negligibly weak force.

Q: Where the primary wave propagates: along axon or along micro-tubules?

A: This question need not make sense if micro-tubules and axon are connected by magnetic flux tubes to form single quantum coherent system. That axonal micro-tubules have constant electric field which is always in same direction could explain why the background soliton sequences and nerve pulses propagate always in the same direction and suggests that the primary wave propagates along micro-tubules. On the other hand, if W exchange between cell exterior and exterior reduces the negative charge of the inner lipid layer then axon could be seen as initiator. This could induce conformational or gel-sol phase transition propagating along micro-tubule and inducing the pair of voltage pulses in turn inducing the fusion of flux tubes at cell membrane which in turn would induce criticality of the axonal membrane. For this option axonal soliton would be a shadow of the micro-tubular soliton rather than completely independent dynamical process.

Q: How nerve pulse velocities are determined?

A: At first glance it seems nerve pulse velocity v could be determined by boundary conditions guaranteeing synchronization of neuronal activity rather than by dissipation as in Hodgkin-Huxley model. As a matter fact, dissipation turns out to affect also v just because it is determined by boundary conditions!

1. Hodgkin-Huxley model would suggest that nerve pulse velocity is dictated by frictional effects as an analog of a drift velocity. The rough order of magnitude estimates for the velocities of conformational waves along micro-tubuli are consistent with the velocities of nerve pulses. The proportionality $v \propto d$ of nerve pulse velocity to nerve axonal radius might be understood as resulting on the dependence on the length of flux tubes connecting axon and micro-tubules and mediating a frictional feedback interaction from axon. Feedback would be naturally reduced as d increases. Feedback interaction could explain also the sensitivity of the thermal parameters of the axonal membrane to the proteins in its vicinity. If the frictional feedback is due to the environmental noise at the axon amplified at quantum criticality this is what one expects. Quite generally, quantum criticality would explain the high sensitivity of the thermal parameters on noise. Saltation cannot be responsible for the higher conduction velocity in myelin sheathed portions of axon. The insulation would reduce the environmental noise at the level of axons and thus reduce the frictional feedback from axon to the micro-tubules.

2. The introduction of friction is however problematic in the recent situation. In absence of boundary conditions Sine-Gordon equation predicts for the propagating soliton sequences a continuous velocity spectrum and friction should affect Ω and V rather than phase velocity v but it is not clear whether it can affect v.

   (a) In this framework the boundary boundary conditions at the ends of the axon or some subunit of axon would dictate the values of v: $\gamma\Omega L/v = n2\pi$ corresponds to periodic boundary conditions (note that $\gamma = \sqrt{1-(v/c)^2} \simeq 1$ holds true). $v = \Omega L/n2\pi$ implies that friction indeed affects also v.

   (b) The relationship states that the time taken by the nerve pulse propagate through the axon is always $T = L/v = n2\pi/\Omega$: this would synchronize neurons and $\Omega \simeq 2\pi$ kHz is suggested by the well-known 1 kHz synchrony difficult to understand in the standard framework where v would be determined by chemistry rather than geometry. Myelin shielding could in this picture guarantee that coherent wave propagation is possible over the entire axon so that boundary conditions can be applied.

(c) This would give $v \simeq \Omega L/n2\pi < \Omega L/2\pi$. $\Omega = 2\pi$ kHz and $n = 1$ would give for $L \in$ [1 cm -10 cm] $v \in$ 10 m/s-100 m/s corresponding roughly to the observed range of values. For short axons velocity would be lower: for $L = 10$ μm one would have $v = .01$ m/s. For longer axons the value of n could be higher or the axon would decompose into structural units for which periodic boundary conditions are satisfied. The sections between Ranvier nodes have length measured in millimeters as are also the lengths of axonal micro-tubules and 1 mm would correspond to a velocity of 1 m/s. The actual velocity for the myelinated sections varies between 18-100 m/s so that basic structural units should be longer. The proportionality of v to the radius of axon would follow from the proportionality of the length of the axon or its basic sub-unit (not longer than $\sim$ 10 cm) to its radius: the simplest geometric explanation for this would be in terms of scaling invariance of the axonal geometry consistent with fractality of TGD Universe. In the standard framework this proportionality would be explained by the minimization of dissipative losses in the case of long axons: one cannot exclude some variant of this explanation also now since friction indeed reduces v.

(d) There is an electric field associated with micro-tubules (always in same direction). Could this electric field play the role of external force feeding energy and momentum to the moving soliton sequence to compensate dissipation so that v would have interpretation as a drift velocity?

Q: Can one understand EEG in this framework?

A: Just like kHz waves also EEG generating waves could correspond to propagating soliton sequences. Since V is not affected, the value of $\hbar$ must be much larger and one must have $\hbar \propto f$, where f defines the EEG rhythm. It is known that EEG amplitudes associated with EEG rhythms behave roughly like $1/f$. This can be understood. By Maxwell's equation the divergence of electromagnetic field tensor is proportional to 4-current implying the amplitude of EEG identified as Josephson radiation is proportional J_0/Ω and therefore to $\hbar$. The propagation velocity $v = \Omega L/2\pi n$ of EEG generating waves is rather slow as compared to kHz waves: for $f = 10$ Hz one would have 10 cm long axon $v = 1$m /s. Synchronization results automatically from periodic boundary conditions at the ends of the axons.

Nerve pulses during EEG rhythms would have much slower velocity of propagation and the duration of nerve pulse would be much longer. The maximal charge transfer would be proportional to $1/\hbar$. It would thus seem that EEG and nerve pulse activity should exclude each other for a given axon. Ω is however smaller so that the generation of nerve pulse is easier unless also ion densities are lower so that J_0 (analogous to gravitational acceleration g in pendulum analogy) is reduced. Perhaps this takes place. The consistency with the propagation velocity of micro-tubular conformational (or even gel-sol-gel) waves might pose additional constraints on v and thus on frequencies Ω for which nerve pulses are possible. That ordinary EEG is not associated with ordinary cells might be due to the fact that $\hbar$ is much smaller: the fractal analog of EEG generating waves could be present but these EEG waves would correspond to faster oscillations in accordance with the view about evolution as an increase of $\hbar$.

Could Hodgkin-Huxley model provide a phenomenological description?

It is now clear that the physics behind Hodgkin-Huxley model is not consistent with the physics behind the TGD based model of nerve pulse. The cell as gel hypothesis excludes Hodkin-Huxley model even without any TGD based physics. If ionic currents were ordinary Ohmic currents as in the case of soliton model and Pollack's model, Hodgkin-Huxley model might be interpreted as a phenomenological description. In TGD framework the dark currents do not dissipate and the model can serve only a recipe to mimic the time evolution of the ionic currents by a judicious tailoring of the time dependence of ionic conductances.

The current associated with a given ion would be proportional to the sum of the electric forces experienced by the particle:

$$I_X = g_X \left[Q_X e (V_{em} - V_X) \right] \quad .$$

In the catastrophe theoretic variant of the Hodgkin-Huxley model [A10], which assumes a wave (Ca^{+2} now) triggering the nerve pulse, the values of the ionic conductivities g_{Na}, g_{Cl} and g_K at resting state are $g_{Na} = 0$, $g_{Cl} = .15\ mmho/cm^2$ and $g_K = .24\ mmho/cm^2$ The values of V_X are $V_K = -77$, $v_{Na} = +50$, $v_{Cl} = -46$, when millivolt is used as unit. The value of the resting potential is $v_R = -65$ mV. The vanishing of g_{Na} at the resting value and down to the point, when nerve pulse is triggered, is assumed in Hodgkin-Huxley model and in the catastrophe theoretic model of the nerve pulse [A10]. The vanishing of g_{Na} codes for the absence of magnetic flux tubes in TGD framework.

11.3.3 Model Of Nerve Pulse Assuming Almost Vacuum Extremal

Both near to and far from vacuum extremals might be important in living matter. Near to vacuum extremals are favored by quantum criticality reflecting as a large degeneracy of ground states assignable to small deformations of vacuum extremals. Also the vision about living matter as 4-D spin glass phase favors almost vacuum extremals. Magnetic flux tubes would in turn be more naturally far from vacua. Also the hierarchy of Planck constants can be associated with the deformations of vacuum extremals so that one would expect them to be important.

At this stage one can make only guesses and it is interesting to consider also the possibility that near to vacuum extremals are more appropriate for the modelling of cell membrane and perhaps even nerve pulse. It is also possible that both kinds of extremals are involved. One must also remember that cells are at different evolutionary levels and the effects of ELF em fields have been observed for vertebrate brain so that ionic Bose-Einstein condensates might appear only in vertebrate neurons. Also vacuum extremals might become increasingly vacuum like as the evolutionary level becomes higher.

Cell as almost vacuum extremal

Although the possible 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 [I54] 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 [L3], [L3] 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 significance 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 [L3] , [L3]

$$\gamma = 3J - \frac{p}{2}Z^0 \quad , \quad Q_Z = I_L^3 - pQ_{em} \quad , \quad p = sin^2(\theta_W) \tag{11.3.5}$$

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 implies $\hbar \sim 10^{13}\hbar_0$ and would mean the scaling of intermediate gauge boson Compton length to that corresponding to the size scale of a large 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 source- 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.

Are photoreceptors nearly vacuum extremals?

The surprising outcome of following considerations is that one could understand the preferred frequencies for photo-receptors [**?**] 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 $\hbar$.

In Hodgkin-Huxley model ionic currents are Ohmic 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 [L47, **?**]. 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 11.3** 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^{+2} currents are known to present during the activation of the photoreceptors. Na^+ current defines the so called dark current [**?**] 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. Interestingly, currents of Ca^{+2} ions and Na^+ Cooper pairs are also in special role that they would give rise to initiation of nerve pulse with values of Planck constant which can be same for both options (near vacuum extremal or far from vacuum extremal). This is seen by studying the expression of the parameter $x = r^2/A(A-Z)$, $r = \hbar/\hbar_0$, appearing in the amplitude of the direct current: the ratio of these parameters is 1.4 in good approximation for same value of Planck constant (see previous section about quantum model for Becker's direct currents). Does this mean that Josephson currents of Ca^{+2} ions and Na^+ Cooper pairs appear in photoreceptors and for ordinary neurons the currents are direct currents? This would require that photoreceptors have higher value of Planck constant so that the Compton length of ion is of order cell membrane thickness.

2. One ends up with the model in the following manner. For Ca^{+2} 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 3 below.

1. The resting potential for photoreceptors is $V = -40$ mV [**?**]. 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^{+2} 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^{+2}, 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^{+2} 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).

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 11.2: 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.

4. In a very bright illumination the hyper-polarization is $V = -65$ mV [**?**], which the normal value of resting potential. For this voltage Josephson energies are predicted to be in UV region except in case of Ca^{+2}. 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^{+2} 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^{+2} 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^{+2} Josephson frequency corresponds to 4 eV metabolic energy quantum as the **Table 11.3** 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.

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 s 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 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.

It is easy to test whether Hodgkin-Huxley model tolerates the inclusion of Z^0 field and the assumption that nuclei and neutrinos or antineutrinos serve as its sources. In the cell scale

neutrinos would indeed serve as a natural source of classical Z^0 fields. The simplest assumption is that neutrino current guarantees that the almomst acuum extremal property prevails during the nerve pulse.

Goldman equation in Hodgkin-Huxley model

Consider first Hodgkin-Huxley model in order to understand how to generalize it to take into account the couplings of nuclei and neutrinos to the classical Z^0 field. In Hodkin-Huxley model the basic equations state flow equilibrium. The basic equation is so called Goldman equation [**?**].

1. Ion current j_A is a sum of two terms:

$$j_A = D_A(\frac{dn_A}{dz} - b_A n_A) \ , \ b_A = \frac{q_A eE}{k_B T} \ , \ E = \frac{V}{d} \ . \tag{11.3.6}$$

   The first term is a diffusion term proportional to concentration gradient of ion and second term a drift term proportional to ion concentration n_A and the electric field E assignable to cell membrane and defined as membrane potential V divivided by the thickness of cell membrane d. Stokes-Einstein equation implies that the coefficient of electric force in drift velocity is expressible in terms of the diffusion constant D_A defining ionic permeability as $P_A = D_A/d$.

2. The equations for the ion currents can be integrated with respect to the coordinate z orthogonal to the cell membrane and give the currents in terms of differences of concentrations outside and inside membrane. The outcome is

$$j_A = D_A b_A \frac{n_A(in)exp(b_A d) + n_A(out)}{1 - exp(b_A d)} \ . \tag{11.3.7}$$

   The change of the sign of the charge changes the sign of b and implies only the replacement in$\leftrightarrow$out and changes of the sign in the above formula. The explicit expression reads as

$$j_A = \mu q_A P_A \frac{n_A)(out) - n_A(in)exp(q_A\mu)}{1 - exp(q_A\mu)} \ , \ \mu = \frac{eV}{kT} \ . \tag{11.3.8}$$

   Note that the multiplication by q_A compensates the change of sign in j_A.

3. The condition that total electric current vanishes reads as

$$j_{tot} = \sum q_A j_A = 0 \tag{11.3.9}$$

   It gives Goldman equation [**?**]. If the charges have same magnitude ($q_A = \pm 1$) the equation can be solved as

$$\begin{aligned} \mu &= log(\frac{w}{v}) \ , \\ w &= \sum_C P_C n_C(out) + \sum_A P_A n_A(int) \ , \\ v &= \sum_C P_C n_C(in) + \sum_A P_A n_A(out) \ . \end{aligned} \tag{11.3.10}$$

Here C refers to positively charged ions (cations) and A to negatively charged ones (anions). In the physical situation only K_+, Na_+, and Cl_- are the interesting ions and only K_+ conductivity differs considerably from zero due to the continual pumping of K_+ ions against the concentration gradient. This gives a more explicit formula

$$eV = k_B T \times log(\frac{P_{K^+} n_{K^+}(out) + P_{Na^+} n_{Na^+}(out) + P_{Cl^-} n_{Cl^-}(in)}{P_{K^+} n_{K^+}(in) + P_{Na^+} n_{Na^+}(in) + P_{Cl^-} n_{Cl^-}(out)}) \ . \tag{11.3.11}$$

relating the resting potential to the ratios of ionic concentrations outside and inside membrane and ionic conductivities which are parameters, which cell is able to modify and does it during the generation of nerve pulse. During nerve pulse in practice only the flows of K_+ and Na_+ ions matter. In the beginning of nerve pulse Na_+ conductance increases and K_+ conductance is reduced. This changes the sign of potential and after that the situation returns to the original one.

Hodgkin-Huxley model for the resting potential for nearly vacuum extremals

One can formulate Hodgkin-Huxley model for the resting potential for exact vacuum extremals by replacing the membrane potential with its Z^0 counterpart since the couplings to em charge vanish assuming that Weinberg angle vanishes for vacuum extremals

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. Also neutrino conductance could be added as a parameter to the model.

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 [J1]. 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 vecotor coupling is following

$$\begin{aligned} (\frac{Z-N}{4} - pZ)Z^0 + q_{em}\gamma &= Q_{eff}\gamma \ , \\ Q_{eff} &= -\frac{Z-N}{2p} + 2Z + q_{em} \ . \end{aligned} \tag{11.3.12}$$

Here γ denotes em gauge potential. For K^+, Cl^-, Na^+, Ca^{+2} one has $Z = (19, 17, 11, 20)$, $Z - N = (-1, -1, -1, 0)$, and $q_{em} = (1, -1, 1, 2)$. **Table 11.3** gives the values of Josephson energies for some values of resting potential for $p = .23$. Rather remarkably, they are in IR or visible range.

$E(Ion)/eV$	$V = -40\ mV$	$V = -60\ mV$	$V = -70\ mV$
Na^+	1.01	1.51	1.76
Cl^-	1.40	2.11	2.46
K^+	1.64	2.47	2.88
Ca^{+2}	1.68	2.52	2.94

Table 11.3: 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 state for photoreceptors and $V = -70$ mV to the resting state of a typical neuron.

Consider now Hodgkin-Huxley model with the resting potential replaced with an effective resting potential due to the classical Z^0 field and the couplings of nuclei to it.

1. The flow equilibrium condition for the Hodgkin-Huxley model changes since the charges (1, -1, 1) for K^+, Cl^- and Na^+ are replaced with the ratios $Q_{eff}(I)/Q_{eff}(K^+) = E(I)/E(K^+)$ giving ratios $(1, E(Cl^-/E(K^+), E(Na^+)/E(K^+)$, which are of same sign.

$$j_{em,tot} = \sum q_{em,A} j_A = 0 \ . \tag{11.3.13}$$

   The resulting equation for the resting potential is more complex and can be solved only numerically. The facts that the charges are of same sign and the conductivity of Cl^- is small, means however that the situation need not change too much qualitatively. Of course, all cell membranes need not be near to vacuum extremal. It could be that only neuronal membranes or only sensory receptor membranes ready to respond rapidly could satisfy this condition.

2. Also neutrino current would contribute to the ionic currents in the modification of the Hodgkin-Huxley model. If the near vacuum extremal property is preserved during the nerve pulse, neutrino current is fixed from the condition that it compensates the ionic contributions to Z^0 current in flow equilbrium. Since nuclei tend to have more neutrons than neutrinos, antineutrino background should more or less compensate the nuclear Z^0 charge so that the antineutrino current should be equal to the total ionic current. The condition that totalZ^0 current vanishes reads as

$$j_{Z^0,tot} = \sum q_{Z^0,A} j_A = 0 \ . \tag{11.3.14}$$

   Here also neutrino current is included and the condition allows to solve it in terms of other currents.

11.3.4 Pollack's Findings And Nerve Pulse

The discovery of negatively charged exclusion zone formed in water bounded by gel phase [I5, L16] (`http://tinyurl.com/ycqtuchp`) has led Pollack to propose the notion of gel like fourth phase of water. In chapters [K78, K38] 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 [K38]. 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 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.

Pollack's findings have powerful implications concerning the model of the cell membrane, ionic pumps and channels and various receptors. The basic implication is the receptors can be regarded as generalized Josephson junctions with Josephson energy replaced with the sum of Coulomb contribution and difference of cyclotron energies of charged bosonic particle at the two side of the membrane. In accordance with ZEO, the thermodynamical description of cel membrane is replaced with its "square root" inand therefore also the model of EEG and nerve pulse. The implications of the model of EEG were discussed in chapter [K38]. The equilibrium distributions of ions are determined by Schrödinger amplitudes proportional to the square root of Boltzmann weight determined by the generalized Josephson energy.

In this framework the general mechanism of nerve pulse generation can be identified as a phase transition changing the value of effective Planck constant at either or both sides of the membrane inducing a change of equilibrium ionic distributions.

11.3.5 Zero energy ontology and quantum model for nerve pulse

In TGD based model of nerve pulse axonal membrane is generalized cylindrical Josephson junction defined by axonal membrane consisting of smaller Josephson junctions defined by membrane proteins.

1. A sequence of mathematical penduli along axon in rotation in the same direction is the mechanical analog. Oscillation frequency Ω transforming to a rotation frequency above critical value is proportional to the resting potential V. When V is overcritical, the pendulum starts to rotate instead of oscillating. The system should be near quantum criticality for the transformation of rotation to oscillation or vice versa.

2. During nerve pulse membrane potential and therefore also rotation frequency is reduced and changes sign and then returns back to the original value. The first guess is that at criticality there is a kick reducing the rotation frequency Ω and continuing to change its sign and then return it to original.

The basic condition is that resting state becomes critical at critical hyper-polarization. There are two options for the resting state.

1. According to the original model [K79], resting state can be regarded as a soliton sequence associated with the phase difference over the membrane. More concretely, the mathematical penduli rotate in same direction with phase difference between determining the propagation velocity of solitons. The rotation frequency is slightly above that for oscillation. There is a preferred direction along axon. This conforms with the reduction and change of sign of potential and thus of Ω.

   Problem: Hypo- rather than hyper-polarization should cause the nerve pulse as a transformation of rotation to oscillation. Something goes wrong.

2. Alternatively, the penduli almost rotate being near criticality for the rotation: the penduli almost reaches the vertical position at each oscillation as required by criticality. That hyper-polarization would cause the nerve pulse as propagating soliton conforms with this idea.

   Problem: Ω and thus V should increase rather than reduce and even change sign temporarily.

Neither option seems to work as such but the first option is more plausible as a starting point of an improved model.

The membrane potential changes sign suggesting quantum jump. Could zero energy ontology (ZEO) based view about quantum jump as "big" (ordinary) state function reduction (BSFR) help? Could nerve pulse correspond to BSFR?

1. Could BSFR occur changing temporarily the arrow of time in ZEO and induce nerve pulse. Could opposite BSFR take place after this in millisecond scale and establish the original arrow of time. Using the language of TGD inspired theory of consciousness [L41], a conscious entity, sub-self or mental image, would die and reincarnate with an opposite arrow of time, live for the duration of nerve pulse and then die and reincarnate with the original arrow of time. Nerve pulse would be a propagation of a temporary neuron death along the axon and would occur as neuron becomes hyper-polarized.

2. In the article [L57] about the recent findings of Minev *et al* [L57] related to quantum jump in atomic physics are discussed. ZEO predicting that the arrow of time is changed in BSFR. This would create the illusion that discontinuous quantum jumps correspond to a classical time evolution leading smoothly and deterministically to the final state.

   This because BSFR leads to a state with reversed arrow of time, which corresponds to a superposition of classical time evolutions leading from the final state to the geometric past and it this, which is observed. This would also explain why the removal of the irradiation inducing quantum jumps has no effect during the transition process and why a stimulation inducing opposite quantum jump can stop the process. Also the findings of Libet related to the active aspects of consciousness [**?**] showing that neural activity seems to preceded volitional act can be understood in this framework without giving up the notion of free will.

   The first half of the nerve pulse would correspond to this apparent evolution to the time reversed final state with opposite membrane potential but actually being time reversed evolution from the final state. The second half of nerve pulse would correspond to opposite state function reduction establishing the original arrow of time. This model looks attractive but many details remain to be checked.

   Why hyper-polarization should cause the temporary death of neuron or its subself?

1. Metabolic energy feed is needed to preserve the polarization of neuron since membrane potential tends to get reduced by second law stating that all gradients are bound to decrease. There should be some maximal polarization possible to preserve using the existing metabolic energy resources.

2. Does quantum jump to a state with opposite arrow of time happen as this limit is reached? Why? Could the metabolic energy feed stop causing the neuron to die to starvation? Why the death of neuron should happen so fast? Could the quantum criticality against the change of rotation to oscillation be the reason. When neuron cannot rotate anymore it would die immediately: the mental image "I am rotating" would die and reincarnate as its time reversal. Does the neuron feeded by metabolic energy become a provider metabolic energy during this period somewhat like dead organisms after their death. Can one conclude that this energy goes to some purpose inside neuron?

11.3.6 TGD based model of nerve pulse and superconducting, possibly conscious computers

The recent dramatic progress in AI has inspired speculation about the possibility of at least rudimentary computer consciousness. I have also written some articles [L104, L105, L111, K102] related to the question whether TGD based new physics could make conscious computers possible. Although the notion of a magnetic body (MB) carrying dark matter in TGD sense of the word does not distinguish between living and inanimate matter, one might argue that the transistor based technology cannot allow conscious computers with a high level of intelligence. Quantum criticality should be realized as criticality at the level of ordinary matter and transistors. Superconducting computing based on superconductivity and Josephson junctions look more promising and here the connection with TGD based view of nerve pulse might provide guidelines.

Superconducting computing, which could be involved with both classical and quantum computation, is a technology, which might provide at least a starting point in attempts to understand how conscious computers might be created in the TGD Universe [L103, L104]. Rapid single flux quantum (RSFQ) is the basic active element in the circuitry and corresponds to single Josephson

junction. The presence/absence of quantized magnetic flux defines the bit. SFQ voltage pulses of duration about picosend are produced by switching of bits in this way. This would allow THz clock frequency f_{cl}.

If f_{cl} corresponds to Josephson frequency $f_J = ZeV/h$, where Z is the charge of the superconducting charge carrier, one obtains an estimate for the voltage as $ZeV \sim .05$ eV. For the cell membrane one has $eV \sim .05$ eV, which is near the thermal threshold at room temperature. The superconducting computations require a temperature of order 10 K so that the value of frequency does not seem to emerge from thermal considerations. The thermal criterion is expected to be satisfied at physiological temperatures for the TGD based generalization of superconducting computers if realized using the same principles as in living matter.

So: could the neuronal and perhaps also cell membranes in general act as analogs of superconducting computers sending sensory information to the magnetic body as Josephson radiation and receiving control commands cyclotron radiation with resonance serving as the basic communication mechanism?

Somewhat surprisingly, the detailed consideration of this question led to an identification of a topological mechanism for how nerve pulses are generated. The counterparts of nerve pulses would be the signalling mechanism also in the case of superconducting computers.

How electromagnetic fields in the TGD Universe different from their Maxwellian counterparts?

One must first clarify how the TGD view of electromagnetic fields differs from the Maxwellian picture.

1. Quantum criticality is essential for the appearance of large values of h_{eff} labelling the scales of long length scale quantum fluctuations. Quantum criticality combined with ZEO would make possible the emergence of life-like features.

2. The gravitational Planck constants $\hbar_{gr} = GMm/\beta_0$ assignable to the gravitational flux tubes of the Earth and Sun are excellent candidates in this respect. The value of $\hbar_{gr}/\hbar$ is $GM_Em/\hbar\beta_0 = (r_S(E)/2L_m)$, r_s denotes the Schwartschild radius of Earth about 1 cm and L_m denotes Compton length of particle with mass m $\beta_0 \simeq 1$.

   The value of $\hbar_{gr}$ depends on particle mass m considered unlike the gravitational Compton length $r_S(E)/2$ (Equivalence Principle). For the Earth, the gravitational Compton frequency is 67 GHz. For the Sun it is about 50 Hz, and is in the EEG range and corresponds to a gravitational Compton length of one half of the Earth radius.

3. In TGD, two kinds of magnetic fields are possible. Monopole flux tubes are something new and rather remarkably, can exist in absence of currents: this makes them ideal for computation. Monopole flux tubes have closed 2-surfaces as cross sections. Flux quantization follows from the homology of CP_2. Monopole flux tubes explain the presence of long range magnetic fields appearing in even cosmological scales [L109, L110] and also the stability of the Earth's magnetic field [L19].

   The magnetic flux tubes having an open cross section with boundary (say disk), correspond to Maxwellian magnetic fields and require the presence of currents (carried by a coil around the flux tubes). For them the flux is conserved but not necessarily quantized.

4. Also in TGD, the topological half of Maxwell's equations, that is Faraday law and the vanishing of the divergence of magnetic field, hold true. Therefore the basic argument for the outcome of the switching of the flux is not affected when ordinary flux tubes are replaced with monopole flux tubes.

Some details of the model of the cell membrane as a Josephson junction

The relation of this picture to the TGD inspired model of nerve pulse [K79] has been already considered in [L104]?

1. The original model of the nerve pulse idealizes the sequence of discrete membrane protein Josephson junctions with a 2-D continuous Josephson junction formed by the lipid layers (or interior and exterior) of the axonal membrane. The mathematical model relies on the Sine-Gordon equation. The key idea is that one can regard the system as analogous to a collection (continuous distribution in the proposed idealization) of gravitational penduli satisfying d'Alembert type wave equation.

   One can consider two kinds of ground states:

   (a) All penduli oscillate in the same phase and with the same amplitude.

   (b) All penduli rotate with the same frequency and in the same phase so that one has a static soliton sequence.

   Lorentz transformations give rise to propagating patterns of this kind.

   For option a), the nerve pulse would correspond to a propagating soliton or a multisoliton in the oscillating background, i.e. a propagating rotational mode of some penduli. For option b), the nerve pulse would correspond to an opposite direction of rotation for some penduli. The fact that the voltage changes its sign during the nerve pulse is consistent with option b).

2. Also the possible role of the axonal microtubules in the conduction of nerve pulse is discussed in [L104]. The transfer of the charges from the microtubule to very long gravitational flux tubes affects the effective charge of the microtubule and therefore membrane potential. This could play an important role in the conduction of nerve pulse.

How could RSFQ generalize in the TGD framework?

How could the notion of RSFQ generalize in the TGD framework? The hint comes from the TGD based model of cell membrane and nerve pulse assigning to the ionic channels of the cell membrane dark Josephson junctions with a large value of h_{eff} making possible high T_c superconductivity.

Consider first the flux quantization in Josephson junctions from the TGD point view.

1. The presence/absence of flux quantum through the junction represents a bit. Switching of the bit in RSFQ means that the flux changes by the unit Φ_0 of magnetic flux. In the simplest situation, the value of flux through the Josephson junction connecting the super conductors, which could have planar or cylindrical geometry, is equal to 0 or Φ_0.

2. When the flux through junction is changed by one unit, Faraday law $\Delta\Phi = \pm\Phi_0 = Ze\int V dt$ implies a generation of voltage pulse propagating along the superconducting wire formed by the coupled cylindrical superconductors. For a constant voltage $V = V_0$, this condition fixes the duration $T = \Phi_0/ZeV$ of the process and this defines Josephson frequency, in turn defining the clock frequency.

The following arguments raise optimism concerning the realization of conscious computers as superconducting computers.

1. Concerning the numbers assigned to RSFQ, the cell membrane looks ideal for the seat of analogues of RSFQs. I have proposed that the cell membrane acts as a sequence of dark Josephson junctions associated with membrane proteins acting as channels and pumps [K79] [L104]. The membrane resting potential $\sim$ .05 eV corresponds to the frequency of 5 THz and is in the same range as the Josephson frequencies assigned with RSFQs. The large value of h_{eff} makes possible high temperature superconductivity and scales up the value of Josephson frequency to $f_J = ZeV/h_{eff}$ so that Josephson frequencies even in EEG scales would be made possible by quantum gravitation in TGD sense.

2. No currents are needed to maintain monopole magnetic fields so that they are ideal for technological purposes. Cell membrane would be a superconductor and membrane proteins would define Josephson junctions. Membrane potential could realize the Josephson frequency $f_J = ZeV/h_{eff}$.

The TGD view of quantum gravitation would suggest that the Earth's gravitational Compton frequency of $f_{gr} = 67$ GHz=.067 THz is important in quantum biology. This frequency is considerably lower than THz and I have proposed it as a clock frequency below with the statistical determinism could fail and make the computer analogous to a life-form.

The TGD view of the basic active unit would differ from RSFR.

1. In TGD, the absence of flux quantum in RSFQ corresponds to two U-shaped monopole flux tubes at opposite sides of the junction associated with the counterpart of the cell membrane and transversal to it. The U-shaped monopole flux tubes can reconnect to form a pair of flux tubes with opposite magnetic fluxes.

   This topological process is fundamental in the TGD inspired view of biocatalysis and water memory [L94]. By the fractality of the TGD Universe, it applies in all scales including, besides cosmological and astrophysical scales [L109, L110], also the scales relevant to atomic, nuclear and hadron physics as has become clear quite recently [L101].

2. What is the effect of the generation/disappearance of a pair of opposite flux tubes? Do both fluxes go through a single junction or does only one of them traverse the junction? In the latter case, the junction would act like RSFQ after reconnection. This is a natural looking working hypothesis. The difference comes from the presence of the flux tube with opposite flux.

   Here one must be very cautious. Flux tubes could make possible the flow of either Ohmic or Josephson current (the more plausible option). If the Josephson currents reside at the flux tubes, the Josephson junction ceases to exist during the nerve pulse. Can one say that the Josephson junction exists also after the splitting of the flux tube pair?

   The fact that ohmic currents flow during the nerve pulse motivates the assumption that the splitting of the pair of flux tubes makes Josephson current impossible and Ohmic currents associated with the nerve pulse appear.

3. Faraday's law should apply to both flux tubes. The appearance of flux tubes would correspond to a generation of opposite fluxes $\Delta\Phi = \Phi_0 = \int V dt$. In the simplest situation the voltage values associated with the flux quanta have opposite values $\pm V_0$. This is very much like in the case of nerve pulse in which the resting potential changes its sign during the first half of the nerve pulse. When the reconnection disappears, the situation would become "normal". The analog of nerve pulse would be generated and propagate along the counterpart of the axon and induce a similar process in all membrane proteins defining Josephson junction.

4. In zero energy ontology (ZEO), the identification of the generation of nerve pulse as a pair of "big" state function reductions (BSFRs) changing the arrow of time temporarily is attractive and would correspond to quantum tunnelling in standard quantum theory.

   An interesting question is whether pump proteins act as channel proteins in reversed time direction and whether the flux tube pairs are associated with pairs of channel and pump proteins.

Critical questions

The first critical question is is how the very low Josephson frequencies ZeV/h_{eff} associated with the large values of h_{eff}, say $h_{eff} = h_{gr}$, can be consistent with the very large values of clock frequency $f_{cl} = f_J = ZeV/h$ needed by a fast operation. It would seem that both h_{eff} and h are needed. Is this possible or are these computers doomed to be very slow?

Should one widen the perspective and take into account the many-sheeted structure of TGD space-time? Is the scale hierarchy of space-time sheets having various values of h_{eff} involved and could it correspond to the onion-like hierarchical structure of the magnetic body (MB) involving increasing time scales as Josephson frequencies? This would give rise to a cognitive hierarchy of MBs serving as "bosses" for lower level MBs and the ordinary Josephson junction would be at the bottom.Could the fast Josephson frequencies define a hierarchy

of computer clocks? Could the pulses of short duration induced by RSFQs induce a hierarchy of frequency modulations of scaled up Josephson oscillations for various values of h_{eff}? This could also make the computer conscious by bringing in the hierarchy of time scales. These levels could correspond to a cognitive hierarchy corresponding to increasing values of $n = h_{eff}/h_0$ identifiable as the dimension of extension of rationals assignable to the space-time sheet considered.

The following simple estimates allow to gain some quantitative perspective concerning the proposal that quantum gravitation could play a decisive role.

1. It is instructive to look at the energy equivalents of the gravitational Compton frequencies for Earth, Moon and Mars for $h_{eff} = h$ (energy is conserved in the the transformation of gravitationally dark photons to ordinary photons).

2. The gravitational Compton frequency $f_{gr} = 67$ GHz of Earth corresponds to the energy $E \simeq .04$ eV near to the energy assignable to the membrane potential.

3. The mass of the Moon is $M_{Moon} = .012M_E$ and scales and correspond to $.56 \times 10^{14}$ Hz, which corresponds to the energy $E \simeq .43$ eV consistent with the size of metabolic energy quantum.

4. The mass of Mars is $.11M_E$ and the corresponding Compton frequency is .67 THz and energy $E = 2.7$ meV which correspond to the mV scale of miniature potentials.

The experimental work of the group of Anirban Bandyopadhyay [**?**] has inspired a proposal of a hierarchy in which the frequency scales come as powers of 10^3. This hierarchy could correspond to a hierarchy of p-adic primes $p \propto 2^{10k}$ and/or hierarchy of effective Planck constants $h_{eff} \propto 2^{10k}$. One cannot associate with it a hierarchy of large masses M appearing in gravitational Compton frequencies. The scale ratio 2^{11} could relate to the ratio $L(127)/L(107) \simeq 2^{10}$ of the p-adic length scales of electron and proton.

The second critical question concerns the temperature needed. Technologically high temperature superconductors are highly favored.

1. In the TGD framework, the cell membrane is assumed to act as a high temperature superconductor at quantum criticality making it an ideal sensory receptor and motor instrument. Biosystems are open systems and a metabolic energy feed would take care that the distribution for the values of h_{eff} is preserved.

2. The fact that the dark matter as $h_{eff} \geq h$ phases of ordinary matter at the space-time sheets of the flux tubes has very weak interactions with the other sheets, in particular the sheet of the ordinary matter, would be decisive.

3. Also zero energy ontology (ZEO) would be highly relevant for maintaining the quantum criticality by making possible homeostasis in which time reversal changes attractor to repulsor and vice versa. When the system begins to roll down from the top of the hill, the arrow of time brings it back.

The key question is whether it is possible to realize the counterparts of bio-superconductors without using organic living matter.

11.3.7 Do neuron groups define homologies of higher-D spaces

Shamoon Ahmed gave a link to a popular article (see this) claiming that the brain is in some sense 11-dimensional. Probably the only thing that M-theory predicts is that the target space of strings is 11-D so that this finding might provide some confirmation of faith for frustrated M-theorists.

In the sequel I will discuss this finding from TGD viewpoint and propose a modified interpretation based on the geometry of icosahedron, one of the 5 platonic solids, which play a key role in TGD, and TGD inspired quantum biology and theory of consciousness.

The dimension 11 in this context looked to me a rather formal notion but one could give it a mathematical meaning.

1. In 3-D one can take tetrahedra, 4-simplexes as building bricks of a discretized manifold. In dimension 11 one has 12-simplexes. These are glued together, which means that n-faces with n varying from 1 to 11 are glued together along $n-1$-D faces.

2. In the case of the brain, one would have groups of neurons, with 12 neurons connected in such a way that one has a connectedness of a 12-simplex. There would be 11- edges meeting at each 12 vertices. Each neuron would be connected to all the other 11 neutrons and would have maximal connectedness, which is very natural if one wants a maximally coherent functional unit.

   The notion of orientation is essential: axons are oriented by the direction of nerve signals which is always the same. The orientation of axons could induce orientations of n-faces. 2-face would correspond to a loop in which signals can rotate in a single direction.

3. Since axons must be present, each neuron must be connected with every other neuron. The geometric connectedness possible in the case of neurons since the axon from a given neuron can branch and have a synaptic contact with the dendrites of several neurons: for n=11-simplex with all other (11) neurons (see this). Note that also a synaptic contact with the neuron itself (autapse) is possible.

   Could one consider also a generalization of this geometric view of a simplex. Could functional coherence of the neuron group serve as a criterion for whether neurons form an n-face? Here the definition of orientation without the notion of axon is the challenge.

4. The interpretation in terms of 11 real dimensions might assume too much and I am reluctant to believe that it has anything to do with M-theory. However, one could realize n-simplexes in this way in 3-space and the orientation of the axon, determined by the preferred directions of signals, would define orientations of higher level simplexes. The idea that these structures could have something to do with geometric cognition allowing us to imagine higher dimensional geometric structures is attractive.

Can TGD add anything interesting to this picture? The appearance of number 12 creates an overwhelming temptation to associate this finding with one particular Platonic solid, icosahedron, having triangular faces. I am not claiming that the proposed interpretation of the findings is wrong but asking whether Platonic solids could add something interesting to the proposal.

1. The 12 vertices of the argued 11-simplex could be also identified as vertices of icosahedron, one particular Platonic solid appearing repeatedly in molecular biology. For an icosahedron, the Hamilton cycle, going through all vertices just once, has 12 vertices and edges [**?**] It would connect each vertex to all other vertices by a unique path having a varying number of edges: 1,2,... The selection of this Hamilton cycle could raise one particular edge path among all possible closed edge paths possible in the maximally connected 12-neutron network in a special position.

2. This icosahedron need not correspond to an ordinary Platonic solid in the Euclidean 3-space. The definition of nearness can be defined also in terms of functional nearness. Indeed, hyperbolic 3-space has been suggested to play a role in neuroscience for neutrons: neurons resembling each other functionally would be near to each other in the hyperbolic metric and in TGD framework this metric is assigned with hyperbolic 3-space H^3 as Lorentz invariant light-cone proper time = constant surface to which the magnetic body (MB) of the brain is assigned as 3-D surface [L69, L88] (see `https://zpr.io/7Bzbagjrk7LE`). The signals from neurons, which are near each other in functional sense, would be sent to nearby points of the MB so that functional nearness would be geometric nearness at the level of MB.

3. Also tetrahedron with 4 vertices and faces and octahedron with 6 vertices and and 8 faces are Platonic solids which have triangular faces representing 2-simplex and could correspond to dimensions d=3 and d=5. Cube with 6 square faces and d=8 vertices is the dual of octahedron and dodecahedron with d=20 vertices and 12 pentagonal faces is the dual of icosahedron. It might be also possible to assign to them a dimension as the number of vertices by using maximal axonal connectedness of vertex neurons as a criterion.

Platonic solids and Hamiltonian cycles as paths going once through each vertex of the Platonic solid and identified as nuclear strings play a key role in the "Platonization" of nuclear and atomic physics [L101] leading to quite precise quantitative vision about basic numbers of nuclear and atomic physics and even hadron physics. The key observation is that the states of $j = l \pm 1/2$-blocks of atoms and nuclei correspond to Platonic solids for $l \leq 6$ (a highly non-trivial fact), which therefore provide geometric representation for the j-block.

Icosahedron is a very special Platonic solid and deserves a separate discussion.

1. Icosahedron is unique among Platonic solids in the sense that it allows a large number of Hamiltonian cycles. Icosahedron, tetrahedron and their Hamiltonian cycles play a fundamental role in the TGD inspired model of genetic code [L15, L56, L70, L77, L98] involving the notion of icosa-tetrahedral tessellation of hyperbolic 3-space involving all 3 Platonic solids with triangular faces.

   Each combination of 3 icosahedral Hamiltonian cycles with symmetries Z_n, $n = 6, 4, 2$ defines a particular realization of the genetic code predicting correctly the number of DNA codons coding for a given amino acid.

2. The model of the genetic code emerged originally as a model of musical harmony. The faces of icosahedron are triangles and would define 3-chords realized as cyclotron frequencies assignable to the vertices of the triangle. Each Hamiltonian cycle would define 20 chords defining a particular harmony whereas the 12 vertices along Hamiltonian cycles would define a 12-note scale, with neighboring vertices representing frequencies related by scaling by 3/2 (quint) modulo octave equivalence.

   One could speak of music of light and since music creates and expresses emotions, the proposal is that different bio-harmonies correspond to different emotional states, moods, realized already at DNA and RNA level. Could these 12 neuron units and possible tessellations (hyperbolic crystals) associated with them relate to the realization of emotions at the level of the brain?

   Physically, the Hamiltonian cycle as a representation of 12-note scale is an analog of a closed string made of flux tubes representing the edges (pipes of organ!)

3. What is fascinating is that hyperbolic 3-space (mass shell in particle physics), playing a key role in TGD, has a unique tessellation/lattice involving all Platonic solids, whose faces are triangles (icosahedron, octahedron, tetrahedron) and also provides a model of DNA making quantitatively correct predictions. I have proposed that this tessellation defines a universal realization of the genetic code realized in all scales at the level of the MB of the system. Could the 12-neuron unit interpreted as 11-simplex relate to one particular realization of this tessellation.

4. Also cubic, icosahedral, and dodecahedral regular tessellations are possible in hyperbolic space (Euclidean 3-space allows only cubic regular tessellation) and they would define the analog of a homology of dimension $n = 7, 11$ or 19 space at neuronal level.

11.4 TGD Based Model For Anesthetic Action

The mechanism of anesthetic action [**?**] (`http://tinyurl.com/yb9pauld`) has remained mystery although a lot of data exist.

Typically anesthetes induce analgesia, amnesia, and immobility. Some anesthetes cause amnesia (brain) but no immobility (spinal cord). I have heard also about anecdotal evidence that anesthetes do not always cause amnesia nor even analgesia.

The first question what comes in mind is whether anesthetes indeed cause a loss of consciousness? In TGD framework self dies when the first state function reduction to the opposite boundary of CD occurs and time reversed self is generated [K109, K7]. Could also anesthetes have the same effect? If so, anesthesia would be like sleep, which need not be unconscious state but could represent time reversed self at "our" level of self hierarchy. This would explain also why we do not have memories about the period during sleep.

The Meyer-Overton correlation suggests that the changes occurring at lipid layers of are responsible for anesthesia but this model fails. Another model assumes that the binding of anesthetes to membrane proteins is responsible for anesthetic effects but also this model has problems. The hypothesis that the anesthetes bind to the hydrophobic pockets of microtubules looks more promising.

The model should also explain the hyperpolarization of neuronal membranes taking also place when consciousness is lost. The old finding of Becker is that the reduction or reversal of voltage between frontal brain and occipital regions correlates with the loss of consciousness. Microtubules and DNA are negatively charged and the discovery of Pollack that so called fourth phase of water involves generation of negatively charged regions could play a role in the model.

Cell memrane can be also seen as a battery and quite recently (towards end of 2016) I learned about battery that after 175 years is still working [L24] [K22]. The explanation would be in terms of Pollacks effect providing also a possible explanation for the production of nuclei and energy in an effect christened originally as cold fusion and later low energy nuclear physics effect (LENR). This battery - as also cell membrane - could be self-loading battery using dark and possibly also ordinary nuclear energy. Combining these inputs with TGD inspired theory of consciousness and quantum biology one ends up to a microtubule based model explaining the basic aspects of anaestesia. The possible loss of consciousness at our level of hierarchy (more precisely, the loss of sensory-motor activity) could be understood as the stabilization of the membrane potential implying that nerve pulses are not generated and sensory input and motor output ceases.

11.4.1 Background

Some facts about anesthetes

To begin with, it is could to list some facts about anaeshtetes.

1. Very wide variety of substances act as anesthetes and there is no clear correlation with the chemical properties of substance. Even noble gases can affect anesthetes. Short range van der Waals interaction involving induction of electric dipoles is a natural candidate for the interaction in question. The increase of atmospheric pressure is known to reduce the anesthetic effect.

2. The anesthetic potency correlation (the Mayer-Overton correlation, see `http://tinyurl.com/ycch96kb`) serves as a valuable guideline as one tries to imagine mechanisms of anesthetic action. The potency of anesthete is proportional to the solubility to lipids. Several mechanisms along these lines have been proposed (see `http://tinyurl.com/yb9pauld`).

   The most obvious guess is that anesthetes are dissolved into lipids and induce perturbation of lipid layer and that the change of properties of lipid layer is responsible for the anesthetic action.

   There are objections against this idea. Anesthetes cause also a fluidization of membrane but so does also a slight temperature increase but is not followed by anesthesia. Further objection is that stereoisomers of anesthetes have very different anesthetic effects. Some drugs highly soluble to lipids have a convulsive effect instead (they are called non-immobilizers). Polar anesthetes are less effective: the reason is that they have to cross blood-brain barrier. The effect of anesthete also vanishes above certain chain length in the case of homologous series of any general anesthetic. For instance, for n-alcoholes carbon chain length of 13 units serves as a cutoff raising whereas the solubility to lipids does not display this kind of effect. Note that t microtubular surface has also this kind of periodicity.

   The conclusion is that lipid solubility is only a necessary condition (allowing the anesthete to get through the membrane) and the lipids in question need not be associated with cell membrane but be hydrophobic pockets of proteins.

3. Second proposal is that anesthetes could bind to membrane proteins. Some anesthetes are indeed stereospecific. The study of this hypothesis led to the observation that general anesthetics can also interact with the hydrophobic protein sites of certain proteins. It is known

that lock-key mechanism is not the general mechanism. Rather, it seems that anesthetes affect protein dynamics in microsecond-millisecond time scale. This suggests that the primary action of anesthetes is at higher level.

What one can conclude?

1. Effects on lipid layers do not explain the findings. Anesthete must be able to go through neuronal membrane. High solubility to lipids certainly helps here. Different anesthetic effect of stereoisomers suggests that the process involves several steps.

2. Lock-key mechanism does not explain all findings: noble gases is a good example and suggests that also van der Waals interactions are important in some cases at least. The ability of anesthetes to bind to hydrophobic pi rings might be important. This kind of rings are associated with tubulin dimers, which suggests that the action of anesthete takes place at the level of microtubules.

Some basic facts about microtubules

1. Microtubules have been proposed to be central for consciousness [**?**]. In [**?**] `http://tinyurl.com/ybdy6lw3` Stuart Hameroff discusses this hypothesis in this commentary of the recent findings of Stuart Kauffmann, Gabor Vattay [**?**] supporting the view that quantum criticality is a general property of biomolecules. Quantum criticality is the key notion of not only TGD inspired view about life [K31, K32, K33, K34] but of entire TGD and realized in terms of hierarchy of sub-algebras of super-symplectic algebra represented as conformal gauge transformations [K28].

   Hameroff argues that the hydrophobic regions of microtubules involving pi rings serve as seats of consciousness and the interaction of anesthetes with them leads to an un-conscious state. The TGD view discussed below is not so simple but assumes that this interaction is central in the process leading to a loss of consciousness. Notice that aromatic rings associated with basic bio-polymers and hallucinogens are examples of these regions highly relevant for consciousness.

2. A related proposal [**?**, **?**] is that in the case of microtubules ferro-electric phase explaining the polarization of microtubules makes possible signalling along microtubule highly relevant to consciousness. Also this view is in accord with TGD based vision, where resonant communications using dark photons with large Planck constant and having universal energy spectrum in the range of visible and UV energies is central. This gives connection also with quantum gravitation but in a way very different from that in the model of Penrose and Hameroff [**?**]. Quantum coherence in even astrophysical scales is essential.

The stabilization of microtubules is due to the negative charge density along them.

1. Microtubular carry negative charge density due to the binding of two GTP molecules to each tubulin dimer (`http://tinyurl.com/y8s3yes5`. The article of Jack Tuszynski [**?**] provides a good view about non-linear liquid crystal model for ferro-electric phase of microtubules and also contains illustration about the average negative charge density of tubulin dimer.

2. Where does the positive charge reside? TGD interpretation for the fourth phase of water suggests that it resides outside microtubules at magnetic flux tubes as dark protons with large value of h_{eff} [K74, K60]. Hu and Wu [**?**] have observed that proton pairs with members at opposite sides of cell membrane have spin-spin interaction frequencies in ELF scale, I have proposed that these protons are dark: TGD inspired model of super-conductivity suggests that they form a super-conducting phase. Also electrons and fermionic ions could be super-conducting with same binding energies for Cooper pairs and this is essential for the TGD based model of cell membrane [K77]. On basis of a model for dark protons I have proposed that they give rise to a representations of DNA, RNA, amino-acids and perhaps even tRNA and that also genetic is naturally realized [K49] and that dark proton sequences accompany DNA: this might make sense since also DNA is negatively charged with 2 negative charges per nucleotide.

3. The empirical rule for the direction of electric polarization is that the neuronal ends of axonal microtubules correspond to minus ends of the microtubule. Remarkably, in the case of dendrites there is fifty-fifty distribution in polarity in the case of vertebrates but for invertebrates the dendrites have positive neuronal end [**?**] (`http://tinyurl.com/y8e7y55f`). This could tell something very deep about consciousness.

   In TGD selves has time reversed variants born when self dies as the first state function reduction to the opposite boundary of CD takes place. Since electric potential changes sign in time reversal, the presence of two kinds of dendrites could relate to memory. Electric voltage changes its sign in time reversal and indeed leads to a loss of consciousness in the scales studied by Becker [**?**]. Could the dendrites correspond to sensory dendrites and memory dendrites? Memories would involve signalling in reversed time direction and memory dendrites. Note that invertebrates would not have memory at this level of self hierarchy.

11.4.2 Earlier TGD Based Model For Anesthetic Action

The molecular mechanism of the anesthetic action is a fascinating unsolved problem of neurophysiology. Noble gases have very weak chemical interactions. Despite this many noble gas such as Xe, Kr, Ar but to my best knowledge not Ne and He, act as anaesthetics. Also chemically non-inert molecules have quite similar narcotic effect so that chemistry does not seem to matter as Hodgkin-Huxley model would predict.

Simplest model for the anesthetic action

It is known that the narcotic efficiency of anesthetics correlates with their solubility in lipids [**?**]. Anesthetics also reduce the melting temperature of the lipid layer. Strong pressure increases the melting temperature and it is known that high pressure brings consciousness back. Thus anesthetic molecules dissolved into the lipid membrane should hinder the generation of the nerve pulse somehow and liquid state of the axonal membrane could be the reason for this. The explanation of the soliton model for the anesthetic action [**?**, **?**] is that the metabolic energy needed to generate an acoustic soliton becomes too high when axon is too high above the critical temperature.

To get a useful perspective note that also the problem why ordinary cell and neuronal soma outside axonal hillock do not allow action potentials is poorly understood. The fact that anesthetes interact so weakly is the basic problem which could be solved by the almost vacuum extremal property predicting that also noble gas atoms are highly charged Z^0 ions so that they are expected to behave very much like ordinary ions in the cell membrane.

1. Pollack's model [I47] suggests that anesthetics could hinder the occurrence of the gel-sol phase transition for the peripheral cytoskeleton. Suppose that $\hbar$ increasing phase transition for the magnetic flux tubes connecting peripheral cytoskeleton to the axon extends them to the axonal exterior and makes possible the influx of monovalent ions inducing gel-sol phase transition. Perhaps anesthetics prevent this phase transition somehow.

2. The obvious idea is that anesthetized axonal membrane (or at least axonal hillock) is just like the ordinary cell membrane. The model for DNA-cell membrane system as a topological quantum computer requires the liquid-crystal property of the lipid layers of the ordinary cell membrane and neuronal membrane outside axonal hillock. If this is the case, then liquid phase for axonal membrane implied by the anesthetic action would indeed make it more or less equivalent with the ordinary cell membrane. Therefore the question is why the liquid-crystal property of the ordinary cell membrane prevents the generation of the action potential. naïvely one could think that the freezing of the membrane means that the mechanical deformation of the membrane occurring during nerve pulse becomes impossible. The presence of noble gas Z^0 ions could induced the freezing. Perhaps they induce a phase transition taking the cell membrane space-time sheet to far from vacuum extremal.

3. Suppose that the phase transition increasing $\hbar$ is induced by the reduction of the voltage over the axonal membrane (assume to be much smaller than cell potential) inducing almost vacuum property and quantum criticality. Somehow the presence of anesthetics would prevent this. Either the voltage over the membrane is increased in magnitude so that the flow

of dark ionic currents to the membrane is not enough to induce quantum criticality or the flow of dark currents is completely prevented by the presence of noble gas Z^0 ions. The first option is more economical and could be tested by finding whether the voltage over the axonal membrane (membrane in a solid state) is considerably smaller than that over the ordinary cell membrane (membrane in liquid-crystal state). The first option also predicts that during sleep the increase of cell potential (hyper-polarization) actually corresponds to the increase of the membrane potential.

Could cyclotron transitions of noble exotic ions in theta and delta bands induce lullaby effect?

Just for fun can consider also more exotic explanation for the anesthetic action. If dark weak force is to have any biological role, the cellular environment should induce a generation of anomalous weak isospin due to the charged color bonds inside nuclei of noble gas. This would obviously relate closely to the anomalous properties of water explained in terms of dark matter hierarchy in [K39, K37]. The color bonds carry also em charge so that noble gas atom with single charged color bond would behave like an ion with nuclear charge Z+1 or Z-1 and electronically like ion with full electronic shell due to ionization (say Cl^- or K^+ in the case of Argon). An important point is that the exotic ions are bosons and can form thermally stable Bose-Einstein cyclotron condensates at $k_d = 47$ flux sheets unlike ordinary ion with mass number differing by one unit.

An interesting question is whether some fraction of Cl^- and K^+ ions are actually exotic Argon ions. Also the long ranged color force and dark weak force with range associated with noble gas nuclei in dark phase could be part of the solution of the mystery.

EEG and ZEG bands above theta band correlate with consciousness. The cyclotron frequencies of ions of anaesthetic noble gases are in theta and delta band as are also EEG frequencies during various stages of sleep but for Ne and He this is not the case. This might not be a mere accident. For instance, one could imagine that the strong resonances in theta and delta bands in EEG induced by Xe, Kr, or A could steal the power otherwise going to higher EEG bands and induce a lullaby effect leading to anaesthesia. This effect of course does not exclude the proposed effect reducing the nerve pulse activity.

According to the general model of EEG [K38], the magnetic flux sheets traversing DNA double strands in cell nuclei come in two varieties corresponding to the two possible quantization of magnetic flux as $Z \int BdS = n\hbar(4)$. For $Z = 1$ the field strength is very near to B_E and for $Z = 2$ to $B_E/2$, with $B_E = .2$ Gauss, the strength of endogenous magnetic field explaining the findings of Blackman and others. For instance, left and right brain hemispheres might correspond to $Z = 1$ and $Z = 2$ and the scale for cyclotron frequencies for right hemisphere would be half of that for left hemisphere. During sleep $Z = 2$ cyclotron frequencies are responsible for EEG via the interaction with Josephson junctions generating the satellites $f_c \pm f_J$ of these frequencies, $f_J = 5$ Hz for $Z = 2$ and $f_J = 2.5$ Hz for $Z = 1$.

The cyclotron frequencies of exotic ions $(Xe^+, Kr^+, Ar^+, Ne^+, He^+)$ are (2.15, 3.57, 7.5, 15, 75) Hz for $B = B_E$ and (1.08, 1.78, 3.75, 7.5, 37.5) Hz for $B = B_E/2$. It would be interesting to check whether EEG contains narrow bands around these frequencies during anesthesia. Also the satellites $f_\pm = f_c \pm f_J$, $f_J = 5$ Hz, could be present. For all noble gas anaesthetics Xe, Kr, and Ar both frequencies are below 7.5 Hz and thus in theta and delta bands. This would encourage to think that the presence of these bosonic exotic ions amplifies the EEG frequencies usually assigned with the theta and delta bands and in this manner induces anaesthesia.

If this is a correct interpretation then it would be essential that K^+ and Cl^- are fermionic ions: otherwise a lullaby effect would result. Note that the exotic ions of Argon can mimic either Cl^- and K^+. Besides producing the lullaby effect, this mimicry could change the effective concentrations of various ions so that large enough reduction of the resting potential could become impossible.

11.4.3 Second TGD Based Model For Anesthesia

In TGD based model for anesthesia magnetic body, supra currents [K76, K77], and dark matter [K40, K31, K32, K33, K34] should be involved. Besides this the findings of Pollack [L16], Becker's

discoveries [**?**], and microtubules, in particular the latest findings of Bandyopadhyay *et al* [**?**, **?**] are expected to be in a central role in the model.

1. The fourth phase of water discovered by Pollack [L16] involving charge separation creating negatively charged regions with sizes up to 100 μm and $H_{1.5}O$ stoichiometry inside negatively charged regions might be involved. Negatively charged linear structures populate living matter. For instance, DNA has 2 negative charges per nucleotide and tubulin dimers have 2 negative charge per nucleotide. Cell interior is also negatively charged. TGD based model [K74, K60] assumes that part of protons go to the magnetic flux tubes and become dark having large non-standard value of effective Planck constant $h_{eff} = n \times h$.

2. Becker's electronic DC currents directed to the wound induce the healing of the wound. Wound develops a negative potential with respect to environment. For instance, frontal lobes are in negative potential with respect to the occipital regions and brain injury generates positive polarization. This means the presence of longitudinal electric fields and ferro-electric phase is a good guess. Becker's discoveries are discussed in TGD framework in [K77, K75]. I have also proposed that Becker currents are supra currents and assignable to microtubules: this assumption is not necessary but possible. Closed circuit must be formed and the return currents could flow as dark supra-currents. Also the currents inside microtubules could be supra-currents, and the ohmic portions of current circuit could fore the semiconductor property.

3. Microtubular ferro-electric property could be the mechanism generating the electric potentials and the action of anesthetes could weaken or destroy these potentials. There is an old discussion of TGD inspired ideas ideas related to microtubules in [K70], and the latest findings of Bandyopadhyay *et al* [**?**, **?**] are modelled in in [K75].

Mostly questions

To end up with TGD based model it is could to start with questions.

1. Could the mechanisms inducing anesthesia and sleep have something in common? Could also anesthetes induce hyperpolarization so that nerve pulses are not generated so much? How the hyperpolarization could be induced?

2. Could there be a connection with DC currents of Becker [**?**]? Could anesthesia reduce the strengths of electric fields of Becker or maybe even reverse their direction. For instance, the electric field between frontal lobes and occipital lobes could change its direction or get weaker.

3. Healing by DC currents means that the damaged body part generates negative potential. DC currents of Becker consisting of electrons make this possible. Could one say that the damaged body part becomes conscious? Could also cell interior, DNA, microtubules negatively charged be conscious.

4. Could there be a connection with microtubules and their ferroelectric phase transition? Could the microtubular longitudinal electric fields be responsible for these electric fields and could DC currents of Becker be associated with microtubules? Is the phase transition destroying microtubular ferro-electricity responsible for the loss of consciousness induced by anesthetes? Could the phase transition change the direction of the electric field? Could this mean change of the arrow of time generating time reversed mental images?

   If the answer to these questions is positive, one might be able to perform reduction of the control of neural activity to microtubular level. Nerve pulses might be induced by a primary wave propagating along microtubules changing locally the direction of the microtubular electric field during the nerve pulse. Temporary time reversal of a microtubular sub-self (mental image) is highly suggestive.

5. Could anesthetes act on microtubules and induce a phase transition destroying their ferroelectric character? Could Becker's DC currents [**?**] flow along microtubules as proposed

[K77, K75]? Consciousness would be lost, when ferroelectricity of microtubules is reduced or disappears. Longitudinal electric field of microtubule associated with its negative charge density would become radial and would induce hyperpolarization.

6. Is there a connection with TGD view about self? Could the change of the sign of voltage be a space-time correlate for time reversal for self [K67] - in the usual interpretation loss of consciousness? Could amnesia about period of "non-consciousness" be due to time reversal changing the sign of the potential.

What could happen in the ferro-electric phase transition?

What could happen in the phase transition making microtubule ferro-electric and in the reverse phase transition leading to a loss of consciousness?

1. Coherent orientation of the microtubular dipoles in longitudinal direction can generate a longitudinal electric field which for long enough microtubules is proportional to the electric charge at the second end. If the orientations of tubulin dipoles are random, the net electric field is also random. The effect of anesthete would be to randomize the directions of dipoles so that the potential between the ends of microtubule would be random. One can wonder whether this field is really strong enough to explain the experimental findings [**?**].

2. Microtubule carries non-vanishing constant negative charge density due to the presence of two GTPs differing from ATPs only in that A is replaced with G attached to the tubulin dimer and stabilizing it.

   The non-topological half of Maxwell's equations also in TGD framework at the level of space-time surfaces. One can however assume it at QFT limit. Consider first the solutions to the Maxwell equation $\nabla^2\Phi = -\rho_q$ for constant charge density ρ_q concentrated on long linear structure, say microtubule. The standard ansatz is that outside of a very long microtubule the potential depends on the radial coordinate ρ only. Φ satisfies Laplace equation $\partial_\rho^2\Phi + \partial_\rho\Phi/\rho = 0$ giving a potential of form $\Phi = klog(\rho/\rho_0)$ creating a slowly varying radial electric field. For this option microtubule would be analogous to a conductor for which the tangential electric field at microtubular surface vanishes. The value of k is proportional to the surface charge density.

3. In the article of Tuzcinsky *et al* [**?**] it is assumed that inside microtubular surface the potential restricted to the microtubular surface satisfies the equation $\partial_z^2\Phi = \rho_q$). A more general ansatz reads as $\Phi = az + bz^2 + c\rho^2$ with $2b + 3c = \rho_q$. The electric field increases along the microtubule and voltage between the ends can be higher than the voltage solely due to a coherent polarization. One can indeed pose this kind of condition as a boundary condition in Maxwell's theory although it makes solution numerically complex.

   The physical picture would be that the electric decomposes to two parts. The first part flows along the microtubule and second part flows in good approximation in the radial direction. The electric field generated by microtubule would be at large distances that of a point like charge but nearby radial field would be weaker than for the solution carrying maximal radial flux and there would be longitudinal electric field carrying part of flux.

   If a phase transition to a situation in which the electric field is radial occurs, the value of the radial flux becomes maximal and could lead to a hyperpolarization of the cell membrane and reduce neural activity. Also the longitudinal electric field would be reduced and would accompany the loss of consciousness in accordance with the findings of Becker. Becker's findings and a basic fact from neuroscience would be understood as aspects of one and same phenomenon.

4. Can one imagine a phase transition changing the sign of the longitudinal electric field of the microtubule. Could this occur for the dendritic microtubules of vertebrates for which both directions of electric field are present? The direction of electric field correlates with the structure of the microtubule so that the reversal very probably cannot occur for an existing microtubule.

5. How the anesthete bound to hydrophobic pi resonance rings generates the phase transition from ferro-electret to non-ferro-electric phase or to a phase with weaker longitudinal electric field? anesthete should induce a phase transition in which the electric field transforms from longitudinal to radial. The interaction with the pi rings defining hydrophobic pockets should somehow redirect the electric flux to radial direction. The simplest possibility is that the anesthete increases the resistance in the longitudinal direction and reduces the current and therefor also the voltage. Also super-conductivity might be destroyed locally.

6. Situation would be also quantum critical. Quantum criticality of TGD Universe is basically due to the huge vacuum degeneracy of Kähler action inducing 4-dimensional spin glass degeneracy, which predicts that a given induced Kähler field allows all symplectic transforms of the space-time surface as its representations. Only classical gravitational fields differ for these representations. Hierarchy Planck constants is one manifestation of the hierarchy of quantum criticalities.

   Also classical gravitation would be relevant and assuming the condition $\hbar_{eff} = \hbar_{gr} = GMm/V_0$, where v_0 is some characteristic velocity in 2-body system involving large mass M and mass m of electron, proton, or heavier particle. TGD predicts macroscopic quantum gravitational coherence [K31, K32, K33, K34] and universal energy spectrum for cyclotron photons (no dependence on the mass m of charged particle mass) highly relevant for the model of bio-photons as decay products of dark photons serving as key tool of quantum control also at the microtubular level. By universality also bio-super-conductivity is universal-that is possible for all charged fermions involved being characterized by same binding energies of Cooper pairs associated with pairs of flux tubes. Also bosonic analogs of supra-currents acting also as spin currents and associated with single flux tube are predicted [K77].

One can relate this model to the TGD based model for the findings of the group led by Anirban Bandyonophyay [**?**, **?**].

1. Microtubules allow two kinds of conformations. For type B microtubules helical symmetry is broken and their is kind of a gap along microtubule. In this phase classical signalling is expected to be possible but macroscopic quantum coherence is restricted to single portion of microtubule helix consisting of 13 tubulins. Also super-conductivity is expected to fail and the conductivity of microtubule is expected to be low. Type A microtubules have helical symmetry since gap is absent. They might be ideal for quantum computation and consciousness since quantum coherence scale would increase from a length of single helical twist to the length scale of entire tubule.

2. There is however a problem: microtubules of type A appear in neither vivo or vitro! This problem can be solved in TGD inspired model [K75].

   The group of Anirban Bandyonophyay [**?**, **?**] have found highly interesting effects of AC electric fields on microtubules at frequency ranges about kHz, MHz, and GHz. The TGD inspired proposal is that the external AC signal can induce a phase transition transforming microtubules of type B to microtubules of type A, and in this manner can make possible quantum computation and consciousness. Dark photons at these frequencies but with energies above thermal threshold - perhaps in the energy range of bio-photons in visible and UV range - would serve as a control tool inducing this phase transition increasing the value of h_{eff}. The generation of the gap would also break the long superconducting wire to pieces and super-conductivity inside microtubule would become super-conductivity in much shorter scale and therefore reduces microtubular conductivity. This implies the reduction of longitudinal electric field and explains the other signatures for the loss of consciousness (reduction of Becker's DC voltage and hyperpolarization).

3. This transition has analog also in TGD based description of both bio-super-conductivity and ordinary high T_c super-conductivity [K77]. There are 2 critical temperatures. At higher critical temperature Cooper pairs are formed at flux tubes carrying antiparallel magnetic field but supra-currents flow in rather short length scale (the analog of B phase for microtubules). At lower critical temperature the flux tube pairs reconnect to from much longer flux tube pairs (microtubules of type A) and give rise to macroscopic super-conductivity. The process

is percolation type process. In the recent case the external AC frequency has the same effect as lowering of temperature.

The model could generalize to other important biopolymers.

1. The presence of negative charge density due to GTP and ATP could provide biopolymers with negative charged density generating the stabilizing electric fields. The negative charge could be due to the generation of fourth phase of water discovered by Pollack [L16] transforming part of protons to dark protons and providing the ionizing electron for GTP or ATP. This suggests a very close connection with metabolism.

2. Also the denaturation of basic biopolymers such as DNA and proteins could rely on a phase transition reducing the longitudinal electric fields made possible by GTP or ATP generated in Pollack's phase transition. In TGD framework one could say that biopolymer loses consciousness.

3. The two strands of DNA could represent sub-selves with opposite time directions. Also brain hemispheres could have opposite arrow of time at some level of self-hierarchy. The other hemisphere would remember and the other hemisphere would pre-cognize (remember in reverse time direction).

Aromatic rings as the lowest level in the molecular self hierarchy?

Of special interest from TGD point of view were the talks of Hameroff and Bandyopadphyay, who talked about aromatic rings (ARs, `http://tinyurl.com/yb492da6`) (`p://tinyurl.com/nrntzs5`).

I have also wondered whether ARs might play key role with motivations coming from several observations.

1. In photosynthesis ARs are a central element in the energy harvesting system , and it is now known that quantum effects in longer length and time scales than expected are involved. This suggests that the ARs involved fuse to form a larger quantum system connected by flux tubes, and that electron pair currents follow along the flux tubes as supra currents.

   DNA codons involve ARs with delocalized pi electrons (`http://tinyurl.com/jqj56wz`), neurotransmitters and psychoactive drugs involve them, 4 amino-acids Phe, trp, tyr and his involve them and they are all hydrophobic and tend to be associated with hydrophobic pockets. Phe and trp appear in hydrophobic pockets of microtubules.

2. The notion of self hierarchy suggests that at molecular level ARs represent the basic selves. ARs would integrate to larger conscious entities by a reconnection of the flux tubes of their magnetic bodies (directing attention to each other!). One would obtain also linear structures such as DNA sequence in this manner. In proteins the four aromatic amino-acids would represent subselves possibly connected by flux tubes. In this manner one would obtain a concrete molecular realization of self hierarchy allowing precise identification of the basic conscious entities as aromatic rings lurking in hydrophobic pockets.

3. Given AR would be accompanied by a magnetic flux tube and the current around it would generate magnetic field. The direction of the current would represent a bit (or perhaps even qbit). In the case of microtubules the phe-trp dichotomy and direction of current would give rise to 4 states identifiable as a representation for four genetic letters A,T,C,G. The current pathways proposed by Hameroff *et al* consisting of sequences of current rings (`http://tinyurl.com/j9pgm6q`) could define the counterparts of DNA sequences at microtubule level.

   For B type microtubules 13 tubulins, which correspond to single 2π rotation, would represent basic unit followed by a gap. This unit could represent a pair of helical strands formed by flux tubes and ARs along them completely analogous to DNA double strand. This longitudinal strand would be formed by a reconnection of magnetic flux tubes of the magnetic fields of ARs and reconnection occurring in two different ways at each step could give rise to braiding.

4. The magnetic flux tubes associated with the magnetic fields of nearby aromatic rings could suffer reconnection and in this manner a longitudinal flux tubes pair carrying supra current could be generated by the mechanism of bio-superconductivity discussed in [K77] and working also for the ordinary high T_c super conductivity. The interaction of microtubule with frequencies in the scales kHz, GHz, and THz scales would induce longitudinal superconductivity as a transition to phase A from phase B meaning generation of long super-conducting wires.

   This view suggests that also DNA is superconductor in longitudinal direction and that oscillating AC voltage induces the superconductivity also now. Bandyopadphyay indeed observed the 8 AC resonance frequencies first for DNA with frequency scales of GHz, THz, PHz, which suggests that dark photon signals or AC voltages at these frequencies induce DNA superconductivity. According to the model of DNA as topological quantum computer DNA is superconductor also in the transversal degrees of freedom meaning that there are flux tubes connecting DNA to a lipid layer of the nuclear or cell membrane [K2, K108].

5. Interestingly, the model of Hameroff *et al* for the helical pathway (`http://tinyurl.com/j9pgm6q`) assumes that there are three aromatic rings per $d = 1$ nm length along microtubule. This number is same as the number of DNA codons per unit length. It is however mentioned that the distance between aromatic rings trp and phe in MT is about $d = 2$ nm. Does this refer to average distance or is $d = 1$ nm just an assumption. In TGD framework the distance would scale as h_{eff} so that also scaling of DNA pathway by a factor 6 could be considered. In this case single tubulin could correspond to genetic codon.

   If $d = 1$ nm is correct, these helical pathways might give rise to a representation of memetic codons representable as sequences of 21 genetic codons meaning that there are 2^{126} different memetic codons [K47]. DNA would represent the lowest level of hierarchy of consciousness and microtubules the next level. Note that each analog of DNA sequences corresponds to different current pathway.

6. What is especially interesting, that codon and its conjugate have always altogether 3 aromatic cycles. Also phe and trp appearing in MTs have this property as also tyr and his. Could these 3 cycles give rise to 3-braid? The braid group B_3 which is covering of permutation group of 3 objects (`http://tinyurl.com/ycnar9sa`). Since B_2 is Abelian group of integers, 3-braid is the smallest braid, which can give rise to interesting topological quantum computation.

   B_3 is also the knot group of trefoil knot (`http://tinyurl.com/of6t3sw`), and the universal central extension of the modular group PSL(2,Z) (a discrete subgroup of Lorentz group playing a key role in TGD since it defines part of the discrete moduli space for the CDs with other boundary fixed [K65]). Quite generally, $B(n)$ is the mapping class group of a disk with n punctures fundamental both in string model: in TGD where disk is replaced with partonic 2-surface.

Why some anesthetes do not prevent motor activity?

Some anesthetes (non-immobilizers (`http://tinyurl.com/jqlncvn`)) do not prevent motor activity and thus break the Meyer-Overton rule. This piece of data could provide a test for the model.

The two kinds of dendrites giving rise to sub-selves with possibly different arrows of time are expected to be similar. Suppose sensory-motor duality realized as dendrites-axon dichotomy. Suppose that the two kinds of dendrites correspond to sensory experience (and pre-cognition as having an idea about what will probably happen) and memories and have opposite arrows of time. If so, there would be no memories about sensory experiences - including pain. The interaction of anesthetes with axonal microtubules would prevent motor activity. If it can happen that an anesthete can bind only to dendrites or to microtubules inside them, one could understand the finding.

What could distinguish between dendrites and motor axons? Size scale is different and could prevent the interaction of some anesthetes with the microtubules of motor axons. Also the microtubules inside dendrites and axons could differ.

11.4.4 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 elec-

trodes 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 [K75] [L20]. 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 [K79]. 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.

It is interesting to compare this Hameroff's vision with TGD view about the roles of microtubules and cell membrane already discussed in [L20]. The new elements are cell membrane as self-loading battery based on the TGD based model for the exclusion zones (EZ) of Pollack [L16] in terms of $h_{eff}/h = n$ phases.

11.4.5 Anesthetes again

The writing of the summary about SSE-2016 conference forced to think again the model for anesthetes in light of the vision about cell membrane as sel-loading battery relying on TGD based model for Pollack's exclusion zones (EZ) [L16] in terms of $h_{eff}/h = n$ phases.

First however a philosophical remark.

1. According to the behavioristic definition of consciousness, the ability to respond to sensory input and perform motor actions are essential aspects of consciousness. To my opinion these abilities correspond to only particular type of consciousness and consciousness might be possible even without neural activities (OBEs and NDEs). In any case, the inability to generate nerve pulse patterns would be an essential aspect for what we call loss of consciousness. This happens if there is hyperpolarization of neuronal membrane.

2. Hyperpolarization means reduced rate of spontaneous nerve pulse generation. This would be achieved if microtubules gain additional negatively charge so that the radial component of microtubule electric field increases. Hence the interaction of anesthetes with the microtubuli should generate this negative charge. One possibility is that Pollack effect [L16] generates in the presence of anesthete negatively charged exclusion zone (EZs) [L16]. The TGD based model assumes that the protons are transferred to the magnetic flux tubes as dark protons and perhaps end up to the exterior of cell membrane and transform to ordinary protons. This would induce hyperpolarization. The neutral anesthete atoms or molecules in turn could be transferred to the microtubules along flux tubes.

Consider next a model for the cell membrane.

1. In TGD Universe cell membranes could be generalized Josephson junctions. The energy of generalized Josephson photons (dark with energies in bio-photon range) would be the difference of cyclotron energies for flux tubes at the two sides of the membrane plus the ordinary Josephson energy. Generalized Josephson photons would take care of communications of sensory data to MB.

   Unless the cyclotron energies at the two sides of the membrane are same, the new contribution would dominate in the communications to MB for large values of h_{eff} since cyclotron energy is proportional to h_{eff}, and neuronal contribution would represent frequency modulation allowing to code nerve pulse patterns to kind of "whale's song". For smaller value of h_{eff} ordinary Josephson energy would dominate.

   There is a temptation to assume that the value of h_{eff} serves as a kind of intelligence quotient of cell. Frequency scale and energy scale for the analog of EEG would serve for the same purpose. For instance, pyramidal neurons responsible for EEG would represent the intellectual elite of brain and ordinary cells could have much smaller value of h_{eff} being say by factor 2^{-10} smaller than for pyramidal cells so that generalized Josephson energy would be of the same order of magnitude as ordinary Josephsone energy and in IR range.

2. Generalized Josephson photons with biophoton energies would also generate Pollack's EZs [L16] by ionizing one proton from hydrogen bonded pair of water molecules. The reduction of the membrane potential below the threshold for nerve pulse generation could reduce the energy of Josephson photons below threshold for generating Pollack's EZs and neuronal membrane would cease to be self-loading battery: this would replace ionic Josephson currents with ohmic currents through cell membrane and generate nerve pulse.

   The objection is that for low values of h_{eff} generalized Josephson energy reduces to ordinary one in IR range and for high values to cyclotron energy in visible-UV range. It is known that IR photons generate EZs in the experiments of Pollack. The process could occur in two steps involving cyclotron radiation - perhaps from MB - kicking of hydrogen bonded water molecules to a state, where proton is almost ionized so that the IR radiation would take care of the ionization. The mechanism generating EZs cannot be different for ordinary cells and neurons. Either the notion of generalized Josephson junction must be given up or in the case of neurons glial cells accompanying also axons generate the IR radiation giving rise to EZs inside axons.

3. It is also attractive to see at least ordinary cell membrane as a self-loading battery [L24]. The generation of Pollack's EZs with negative charge and dark proton charge at magnetic flux tubes of the associated MB could make cell a self-loading battery [L24].

   Generalized Josephson photons from cell membrane or cyclotron photons could generate EZs by kicking protons to dark protons at flux tubes of MB of the cell. The energy must be in some critical range in order that this can happen. For too small energies the process stops. Besides ionic charge distributions EZs and the delocalized dark proton charges and the flux tubes extending beyond cell interior would be responsible for the resting potential.

   EZs are not expected to be completely stable. The $h_{eff} \to h$ phase transition would bring dark protons back as ordinary protons and destroy EZs and reduce the magnitude of membrane potential. There could be a competition between the generation and destruction of EZs by $h_{eff} \to h$ phase transition.

4. This picture is enough to explain the effect of anesthetes. Anesthetes at microtubules would generate a negative charge assignable to additional EZs thus increasing the magnitude of the membrane potential. This would imply stable hyperpolarization preventing the generation of nerve pulses.

What about generation of nerve pulses in this framework? I have suggested a TGD based model for nerve pulse [K79] relying on the idea about cell membrane as array of Josephson junctions consisting of membrane proteins (channel and pump proteins) but the model leaves open what exactly generates the nerve pulse. The expectation has however been that microtubules play a key role in the generation of nerve pulse. A charge wave with positive charge propagating along microtubule could induce the reduction of the membrane potential and lead to a generation of nerve pulse as a secondary wave.

1. The propagation of $h_{eff} \to h$ phase transition followed by its reversal along axon interior could serve as a weak control signal inducing the nerve pulse propagation at quantum criticality. This phase transition could be assignable to microtubules. Battery would temporarily discharge during the nerve pulse. If glial cells generate the EZs making axons glial-cell loaded batteries then the return back to the normal state after nerve pulse would be possible by the presence glial cells.

2. During nerve pulse either the generation of EZs ceases and/or the existing EZs suffer an h_{eff} reducing phase transition so that flux tubes are shortened and the positive dark charge returns to EZs and cell membrane potential is reduced. The generation of nerve pulse is usually modelled using ohmic ionic currents, which suggests that quantum coherence is lost by a reduction of h_{eff}, which is predicted to be proportional to ion mass so that cyclotron energy spectrum is universal and in visible-UV range for bio-photons.

3. Nerve pulse could be a "secondary wave" induced by a wave of positive charge propagating along microtubule. This wave of positive charge would rather naturally result from the

reduction $h_{eff} \to h$ and return back to h_{eff}. A pair of phase transitions dark-ordinary-dark would propagate along the microtubule. The unidirectionality of the propagation direction would be forced by the fact that it can begin only from axonal hillock. Axonal hillock contains a large number of voltage gated ion channels, which would serve as generalized Josephson junctions in TGD framework.

4. What one can one conclude about the development of total charge during the time development of membrane potential $V(t)$? Nerve pulse corresponds to certain segment of axon and lasts for few milliseconds. The cell membrane voltage goes from resting potential $V(t = 0) = V_{rest}$ to approximately $V(t = T) = -V_{rest}$ and returns back. The total charge in cell interior defines the value of electric field E at the interior side of cell membrane and approximation interior as conductor, the value of Ein good approximation one has $V = Ed = Q_{cell}d/4\pi R^2$ in spherical geometry and $V = Ed = dQ_{tot}/dld/2\pi R$ in cylindrical geometry of axon. Here Q_{tot} is the charge of the piece of axons at which nerve pulse is located. Total charge is sum of microtubular charge Q_{mt} serving as a control parameter and the total ionic charge Q_I changing due to the presence of ohmic ionic currents during the pulse (ionic currents are Josephson currents except during nerve pulse).

   To get some quantitative grasp, let us idealize the situation by assuming that during nerve pulse the negative microtubular charge $Q_{mt}(0) < 0$ goes to $Q_{mt}(T) = 0$ for $V(T) = -V_{rest}$ (EZs disappear totally) and returns back to its original value as the phase transition returning the value of h_{eff} occurs.

   One has $Q_{tot}(0) = Q_{mt}(0) + Q_I(0)$ before the nerve pulse. At $V = -V_{rest}$ one has $Q_{tot}(T) = -Q_{tot}(0)$, which gives $-Q_{tot}(0) = Q_I(T)$. This gives $Q_{mt}(0) = Q_I(T) - Q_I(0)$.

   What can one say about the magnitude of Q_{mt}? If this charge serves control purpose and if the system is kicked off from quantum criticality, the change of Q_{mt} need not be large so that no large modifications of the ordinary model of nerve pulses are needed. The negative microtubular charge is partially due to the GTPs along microtubular to which EZs are associated. The value of resting potential of order .06 eV at threshold for nerve pulse generation and estimates for linear ionic charge densities $dQ_I(0)/dl$ and $dQ_I(T)/dl$ and $Q_{mt}(0)/dt$ would allow to test the model. The $h_{eff} \to h$ phase transition outside quantum criticality would take place in millisecond time scale.

The distinctions between neurons and ordinary cells allow to invent objections against the proposed scenario.

1. Ordinary cell membrane should act as a self-loading battery with Josephson radiation generating Pollack's EZs. Axonal microtubules are missing but the cytoskeleton consisting also of microtubules is present. Inside the cell soma the microtubules meet the cell membrane transversally. There is also T-shaped antenna like structure involving microtubules whereas ordinary neurons have axonal microtubules. Also now a microtubular positive charge generated by $h_{eff} \to h$ phase transition could induce the reduction of membrane potential.

2. Why the analog of nerve pulse does not take place also now? In the case of cancer cells membrane potential is reduced and can become even vanishing, and one might think that the lack of recovery is due to the absence of glial cells taking care that EZs are generated. For too low Josephson energies the self-loading would stop and due to the spontaneously occurring $h_{eff} \to h$ phase transitions, the membrane potential would be gradually reduced.

   In the case of neurons the $h_{eff} \to h$ phase transition would occur fast. The transition away from quantum criticality could cause this since long range quantum fluctuations would disappear. The value of membrane potential or the difference between neuronal and glial membrane potentials could serve as a critical parameter changing as the membrane potential is reduced. The quantum criticality of ordinary cell membrane would be analogous to self-organized quantum criticality. That of neuronal axon to quantum criticality induced by glial cells.

11.4.6 TGD interpretation of new experimental results about the mechanism of anesthesia

I received a link to a highly interesting popular article with title "*Century-Old Scientific Debate Settled: Anesthesia's Effect on Consciousness Solved*" (`https://tinyurl.com/yd4ztmph`). The article tells about a study from Scripps Research published in the Proceedings of the National Academies of Sciences (PNAS). The paper [**?**] "*Studies on the mechanism of general anesthesia*" has appeared in PNAS (`https://tinyurl.com/y8oa97eo`). In addition to Lerner and Hansen, the authors are Mahmud Arif Pavel, E. Nicholas Petersen and Hao Wang, all of Scripps Research.

I have pondered possible mechanism of anesthesia in TGD framework several times earlier [K79] [L20] and it is interesting to see whether the findings allow to make earlier insights more detailed or even develop new ones.

What was observed

According to the popular article the discovery by chemist Richard Lerner, MD, and molecular biologist Scott Hansen, PhD, settles a century-old scientific debate about whether anesthetics act directly on cell-membrane gates called ion channels, or do they somehow act on the membrane to signal cell changes in a new and unexpected way. The conclusion of the researcheres is that anesthetic action is a two-step process that begins in the membrane. The anesthetics perturb ordered lipid clusters within the cell membrane known as "lipid rafts" to initiate the signal. There are two kinds of clusters involved and known with names GM1 and PIP2.

What was observed was following.

- A shift in the GM1 cluster's organization, a shift from a tightly packed ball to a disrupted mess occurred first As GM1 grew disordered, it spilled its contents, among them, an enzyme called phospholipase D2 (PLD2). Melting is a good analog for what happens. Gel-to-sol transition in cytoplasm is second analogy.
- PLD2 moved like a billiard ball away from its GM1 home and over to a different, less-preferred lipid cluster called PIP2.
- This activates key molecules within PIP2 clusters, TREK1 potassium ion channels and their lipid activator, phosphatidic acid (PA) are among them. The activation of TREK1 potassium channels releases potassium hyper-polarizing the nerve and it makes it more difficult to fire. Nerve pulse generation rate becomes low and leads to a loss of consciousness - at least in clinical sense. Something analogous to this could happen when one falls in sleep.

In the sequel I try to understand in the framework provided by TGD inspired model of cell membrane and nerve pulse [K79], compare these findings to TGD inspired views about anesthesia based on hyperpolarization, and also try to build a bridge from TGD description provided by a generalization of thermodynamics forced by zero energy ontology (ZEO) predicting that in ordinary state function reduction the arrow of time changes [L63, L72].

TGD background

In the following Pollack effect and its generalization are discussed, ZEO based view about self-organization involving time reversal as key element is compared to the non-equilibrium thermodynamics (NET) based approach, and the TGD based view about nerve pulse generation and EEG is discussed.

1. Pollack effect as starting point

The generalization of Pollack effect [I48, L16, I82, I66] plays a key role in TGD inspired biology.

1. TGD based model of cell membrane relies on a generalizaton of Pollack effect so that it would allow also to other ions - at least positively charged ions inside neuronal (cell) membrane. Pollack effect occurs in presence of energy feed such as IR photons, and means charge separation in water bounded by gel so that negatively charged exclusion zone (EZ) is formed. TGD

interpretation is that part of protons goes outside EZ to magnetic flux tubes and form dark proton sequences having effective Planck constant $h_{eff} = nh_0 > h$ and forming macroscopic quantum phase. Dark particles at magnetic flux tubes of magnetic body of system (MB) would control its dynamics like master and induce coherence as forced coherence.

EZ has the strange property that it drives out impurities. The interpretation is that the arrow of time is change at MB controlling EZ and induces effective change of the arrow of time at EZ differing from the standard arrow of time of observer. DNA nucleotides involve negatively charged phosphate ion, which leads to the proposal that they are accompanied by magnetic flux tubes parallel to them carrying dark proton triplets as a representation of genetic codons [L21, L56].

Negatively charge entities appear abundant in biology.

(a) Cell interior is negatively charged, which suggests similar charge separation with positive charge assignable to dark ions at the magnetic flux tubes outside cell. Fermionic ions such as K^+, Na^+,.. could form Bose-Einstein (B-E) condensates of Cooper pairs whereas bosonic ions like such as Ca^{2+}, Mg^{2+}, Fe^{2+} could as such form B-E condensates. It is not clear whether also negatively charged ions like Cl^- form B-E condensates at flux tubes and whether they are in the interior or exterior of cell.

(b) Microtubules carry constant negative charge density per unit length realized in terms of GTP molecules suggesting that they are accompanied by parallel flux tubes carrying say dark protons. Microtubules could be partially responsible for the negative charge of cell and could be related to the control of membrane potential.

(c) ATP has charge -3. This forces to ask whether there is charge +3 of 3 protons associated with a magnetic flux tube accompanying ATP. Could the 3 protons form the analog of genetic codon so that information processing might take place already at this level?

2. Pollack effect would basically transform part of ordinary ions in cell interior to dark ions or their Cooper pairs outside cell at flux tubes. Note that also the analogs of 3-proton units can be considered for positive ions. This would require energy feed, which need not come from metabolic energy. Integral proteins acting as ion channels do not require ATP to function and are a good candidate in this respect. Their opening could make possible Pollack effect for ion. Ion pumps are also integral proteins and could transfer the ions produced in the decay of Cooper pairs to ordinary ions back to cell interior.

2. ZEO based thermodynamical description of self-organizing cell

TGD leads to a new kind of thermodynamical description of cell as an open self-organizing system. Cell is indeed an open self-organizing system requiring metabolic energy feed. The standard description would be using non-equilibrium thermodynamics (NET). ZEO allows both arrows of time and and the arrow of time changes in ordinary ("big") state function reductions (BSFRs) possible in arbitrary long scales. This forces a generalization of thermodynamics allowing a new kind of description.

Dissipation with reversed arrow of time corresponds to generation of gradients and gradients as seen by observer with standard time direction, and energy feed needed by self-organization corresponds to dissipation of energy by self-organizing system in reverse time direction. The arrow of time could be different from standard one in long time scales only at the level of MB carrying dark matter and can induce its effective change at the level of ordinary matter.

The energy of particle increases with h_{eff} so that generation of dark phases and the preservation of h_{eff} distribution requires energy feed. Hence one can see self-organization as a direct evidence for the notions of MB and ZEO.

How does TGD description relate to the standard description of cell in terms of NET differing from the ordinary thermodynamics by the presence of energy feed?

1. In standard thermodynamical description the presence of dark matter is not assumed. Therefore the description takes into account only the ordinary matter. For living cell the differences

between ion concentrations are in sharp conflict with naïve expectations for ions like K^+ (concentration is considerably higher in the cell interior). They are explained by using chemical potentials μ as parameters. Their values are determined experimentally from measured ion concentrations. Their values would be basically determined by the metabolic energy feed: here NET enters the picture.

2. The basic quantity is Gibbs energy $G = E - TS$, whose minimization corresponds to second law of thermodynamics. The energy minimization and entropy maximization compete and there is a competition between energy and entropy. Giggs energy for single particle corresponds to chemical potential $\mu = e - Ts$ at single particle level. Given process is thermodynamically favored at single particle level if μ decreases in it.

3. For instance, the measured density of K^+ ions is much higher inside cell than exterior - this corresponds to the fact that dark K^+ ions or of their Cooper pairs at flux tubes are not observed. When channel is opened the K^+ ions flow to the exterior of the membrane provided this corresponds to a decrease of μ. For given ion there is also a certain value of membrane potential for which there is no flow.

   In TGD framework Pollack effect transforming K^+ ions to their dark variants transferred to the flux tubes outside cell and possibly forming Cooper pairs would be the description. The safest assumption is that ions are at flux tubes at both sides but that at either side the value of h_{eff} is minimal. Also phase transitions changing h_{eff} for flux tubes are expected to occur and play a key role in TGD based model for bio-catalysis.

4. An open problem is whether the phenomenological description of ordinary matter in terms of NET is equivalent with the ZEO based description in which also dark matter is taken into account. For instance, Pollack effect for protons requires energy feed. It generates charge separation, which generates negative Coulomb energy. The Coulomb repulsion between charged protons at flux tube generates positive energy. The model as dark nuclei implies that there is also scaled dow nuclear binding energy involved. The value of entropy generated in this manner depends on the scale of de-localization at MB. If macroscopic quantum phase is generated, one expects that the generated entropy is actually small.

5. It would seem that ion channels, which do not require ATP, involve the transfer of ordinary matter to dark matter at magnetic flux tubes. Could ion pumps requiring ATP be responsible for the transfer of ordinary ions between cell interior and exterior against gradient of chemical potential? Could they correspond to standard arrow of time?

3. EEG and nerve pulse generation in ZEO

TGD leads to a model of nerve pulse and EEG [K79, K38, K81].

1. Cell membrane is a generalized Josephson junction in the sense that there are flux tubes at both sides of the membrane connected by a flux tubes through cell membrane. The energy assignable to the ion in junction is sum of two terms. The first term is the ordinary Josephson energy given by Coulomb energy. Second terms is the difference of the cyclotron energies of ion associated with the flux tubes at the two sides of the membrane. The generalized Josephson radiation generated by this system consists of dark photons travelling along magnetic flux tubes to the part of MB much larger than the system. The Compton length of EEG radiation at Schumann frequency 7.8 Hz gives an estimate of order Earth circumference for the size scale of MB.

2. The sensory part of EEG mediating sensory information to MB would be assigned with the generalized Josephson frequencies modulated by the variation of membrane potential and in this manner coding the sensory data. If the signal is received at certain resonance frequencies it corresponds to a sequence of peaks corresponding to critical values of membrane potential.

   MB containing cyclotron B-E condensates would receive this radiation resonantly and respond by control signal consisting of dark cyclotron radiation possibly mediated through genome (and possibly also microtubuli) and inducing biological effects. They would emerge by a

transition $\hbar_{eff} = h\hbar_0 = h_{gr} = GMm/v_0 \rightarrow h$ producing ordinary photons identifiable as bio-photons in visible and UV range [K13, L11]. These would induce molecular transitions.

3. h_{eff} hierarchy allows to interpret the generation of nerve pulse as a quantum jump in neuronal scale. The change of the arrow of time correspond to the change of the sign of the membrane potential temporarily. This process would liberate energy needed to preserve the thermodynamical non-equilibrium state but regeneration of standard arrow of time would require metabolic energy so that energy would be lost. For instance, generalized Josephson radiation would use part of the energy.

   Neural membrane is quantum critical against generation of nerve pulses by macroscopic quantum jump changing the arrow of time (automatically) - as a matter of fact, the Josephson energy for ion Cooper pairs is near to thermal energy. This makes cell membrane an ideal sensory receptor.

4. Quite generally motor actions correspond in TGD framework BSFRs whereas sensory perception corresponds to a sequences of "small" state function reductions (SSFRs). This would suggest that the EEG waves from the cell membrane as sensory input have standard arrow of time and control signals from MB comes as EEG waves with opposite arrow of time. One might also speak of time reflection of the positive energy signal. A detailed model for the sequence of SSFRs leads also to a model for what personal memories are [L63, L72].

What happens to GM1 fart is essentially melting.

1. Melting phase transitions - analogous to gel-sol transitions for cytoplasm - occur in the lipid layer also during the propagation of nerve pulse and has been proposed to accompany a propagation of soliton [**?**] (`https://www.pnas.org/content/102/28/9790`). TGD based model of nerve pulse [K79] assumes that in the resting state of axon there is a sequence of solitons propagating along the axon mathematically. The chain of the proteins representing ion channels (and possibly also pumps) as Josephson junctions would be analogous to a chain of rotating mathematical penduli with constant phase difference.

2. Nerve pulse would correspond to a propagation of a perturbation for which some penduli oscillate rather than rotate. The local transformation of rotation to oscillation would correspond to a melting phase transition propagating along axon.

3. One cannot however exclude the possibility that the Josephson penduli are not kicked to oscillation but to a rotation in opposite direction. This would conform with the proposal of [**?**] that nerve pulse involves propagation of some kind of soliton.

   If this is true, the ions at two sides should be at flux tubes with different values of h_{eff} and the values of h_{eff} are effectively permuted at two sides to change the sign of membrane potential. This requires transfer of energy between interior and exterior. The change of the sign of membrane potential suggests local time reversal and if BSFR occurs, this must happen. If BSFR occurs, some self - neuronal mental image - at exterior dies and re-incarnates with opposite arrow of time in the interior. The observer with standard arrow of time would see ions to flow from the MB of the neuron to interior flux tubes for which h_{eff} is increased. The naïve expectation is that also the roles of channels and pumps are changed.

4. It would be natural to assign melting transition with the reduction of membrane potential and initiation of the time reversed period. The possible melting outside neuron would be accompanied by freezing in the interior. Gel-sol phase transitions in cytoplasm could accompany the nerve pulse propagation. Cavitational fluctuations of water and microtubule disassembly are known to be accompanied by gel-sol phase transitions and of emission of bio-photons and IR light [I9] (`https://tinyurl.com/ya33kdzt`). Photons are indeed in central role also in the generation of Pollack effect as providers of metabolic energy to realize the transition.

   Gel like states would correspond in TGD picture states of water in which the value of h_{eff} for the flux tubes is increased and thus to ordered states with higher number theoretic "IQ" having interpretation as dimension of extension of rationals [L61, L71, L68]. The increase of

h_{eff} requires energy and gel-sol phase transition would correspond to a reduction o h_{eff} and liberate stored metabolic energy. One expects gel-sol phase transitions for cellular water to accompany the propagation of nerve pulses. One can imagine that the energy liberated in gel-to-sol transition induces sol-to-gel transition. This would naturally allow interpretation also as information transfer too?

What could happen in anesthesia?

Anesthetes - often noble gases - are expected to have rather weak chemical effects. This suggests that the mechanism inducing hyperpolarization is not purely chemical.

1. It would seem that GM1 clusters and PIP2 clusters correspond to two different equilibria in which the dark K^+ concentrations at dark flux tubes are different and therefore also membrane potentials. The role of the anesthete and of the control step inducing sleep would be to replace GM1 with PIP2. The anesthete dissolving into lipid layers could induce its melting by lowering the density of lipids in lipid-crystal and in this manner induce the decay of GM1 clusters. The interpretation of lost coherence could be in terms of reduction of h_{eff}: if BSFR occurs, GM1 could be said to die. The decay of the GM1 clusters could be thus seen as analog of decay process in general liberating energy used in the next step of the process.

2. What could happen in the decay of GM1 cluster, which expands from tightly packed ball and looses is order? The twistor lift of TGD [L64, L58] predicts length scale dependent cosmological constant Λ characterizing various structures in all scales and the possibility of phase transitions reducing the value of Λ, scaling up the size of the structure in question, and liberating energy. Could also GM1 be characerized by Λ decreasing in the transition and could the liberated energy be used as metabolic energy in the transfer of K^+ ions?

3. The PLD2 molecules (containing phosphate) are said to move like billiard balls to PIP2 clusters, which suggests that they could travel along magnetic flux tubes connecting the two systems. PLD2 molecules act as catalysts and could help to activate TREK1 K^+ channels and their lipid activator, phosphatidic acid (PA) containing phosphate with charge -2.

   All these molecules involve negatively charged phosphate ions and this could relate to the generation of charge separation by Pollack effect. PIP2 involves 3 negatively charged phosphates and it binds to the TREK1. The negative charge from phosphates bound to TRKE1 could make it part of an analog of EZ. I do not know whether one has excluded the possibility of ATP $\rightarrow$ ADP type mechanism.

4. It is not clear what happens at the level of energetics. In ZEO picture the opening of K^+ ion channels would make possible a transfer of K^+ ions by Pollack effect to their dark variants possibly forming Cooper pairs at MB at the other side of neural membrane. If this requires metabolic energy, it is not provided by ATP.

   In NET picture Gibbs free energy should decrease if the process is spontaneous as suggested by the absence of ATP. This could be the case also now at least approximately. There could be quantum criticality in the sense that there is large number of states of neuron with essentially same energy or with energies differing only slightly but with different membrane potential.

   The increase of the membrane potential reduces the rate for the spontaneous generation of nerve pulses. Nerve pulse generation is expected to release energy but the regeneration of membrane potential back to its original value requires energy. Hence one expects that the anesthetic state saves metabolic energy as also sleep state is expected to do. Note that the feed of metabolic energy could corresponds quite generally to dissipation in opposite time direction. Could the MB of PIP2 cluster live in opposite time direction - as also GM1 cluster when active - and get its metabolic energy making possible the transfer of K^+ ions in this manner?

5. What is the role of the anesthete? Meyerton-Overton hypothesis states that the potency of anesthete correlates with its liquid solubility. The anesthete dissolved into the 2-D liquid-crystal formed by lipid layer should somehow induce the decay of GM1 cluster: the dissolved

anesthete could force the reduction of density of 2-D liquid crystal if the total pressure is preserved. Could this decay liberate provide the metabolic energy needed in Pollack effect? Anesthete dissolves spontaneously. In standard picture the interpretation would be that this reduces Gibbs energy G. Does this liberate energy or is the increase of entropy enough to reduce G?

Questions

The foregoing speculative picture raises several questions.

1. The falling to sleep could involve similar transition. What happens to conscious experience in anesthesia and sleep. Sensory input from cell membranes to MB disappears and also motor control from MB becomes impossible but does this really mean loss of consciousness? Could the experience be nearer to a meditative state?

2. The arrow of time changes inside EZs assignable to negative charge in Pollack effect. Could PIP2 cluster be contained in EZ and thus have also reversed arrow of time. Could EZ property be tested? Could also the GM1 cluster have reversed arrow of time and be responsible for the transfer of different kind of ions?

   In ZEO "big" (ordinary) state function reduction (BSFR) corresponds quite universally to death and re-incarnation with opposite arrow of time for conscious entity involved. Could falling asleep be BSFR at some level of self hierarchy. Could GM1 clusters as conscious entities die and could their decay be analogous to ordinary decay process and provide both building bricks (PLD2) and metabolic energy for PIP2 clusters? Could this be interpreted as a kind of birth or wake-up for PIP2 clusters? Could the re-incarnated GM1 clusters live in opposite arrow of time?

3. K^+ channels represent only one particular kind of ion channel and there are many ways to control the ion flux. Could all ion channels rely to Pollack effect? What about on pumps. Could ion pumps be channels but with opposite arrow of time?

4. Quantum consciousness theorists like Hameroff have speculated about the role of microtubules in the action of anesthetes. The proposal is that the anesthete could bind in the hydrophobic pocket of microtubule. The recent findings seem to exclude this option.

   Microtubules however carry large negative charge density due to the presence of GTP molecules (analogous to ATP molecules), which strongly suggests the existence of magnetic flux tubes parallel to them and carrying dark protons or possibly some other positive ions. Microtubules are highly dynamical in quantum critical phase. Could their varying negative charge control the membrane potential by generating opposite varying charge at MB outside cell membrane by Pollack effect (I have discussed anesthetes in several sections of [K79]). Could the transition to sleep be controlled by the microtubular level using a variant of the mechanism discussed as a tool?

   Concerning the possible the source of metabolic energy, it is known that $GTP \to GDP$ cycle occurs [**?**] (`https://tinyurl.com/yapdcotf`). Could this mechanism serve as an analog of $ATP \to ADP$ with metabolic energy stored in metabolites replaced with the metabolic energy carried by dark photons transforming to bio-photons?

5. What is interesting is that at the endogoneous magnetic field with value $B_{end} = .2$ Gauss assigned with monopole flux tube part of Earth's magnetic field with nominal value of $B_E = .5$ Gauss the cyclotron frequency of K^+ ion (and Cooper pair) is 7.5 Hz. Could dark Schumann resonance photons induce cyclotron transition of B-E condensate of K^+ Cooper pairs? A magnetic field oscillating frequency of with 7 Hz frequency not too far from the lowest Schumann resonance frequency and cyclotron frequency of K^+ ions appears also in the experiment of Montagnier *et al* [L45] strongly suggesting remote replication of DNA.

11.5 Many-Sheeted Neuron

TGD approach allows to make educated guesses concerning the interpretation of various phenomena in neuronal level. This section has been written much before the input from DNA as TQC and the realization that microtubule-cell membrane braids could serve as quantal sensory memory storage based on the braiding of the magnetic flux tubes emanating from the amino-acids of tubulin molecules. This implies obvious updatings of the text of this section left to the reader.

11.5.1 Neuronal Consciousness

The fractality of consciousness encourages the view that neurons and corresponding magnetic bodies are conscious organisms having receiving sensory input and forming sensory representations at their magnetic bodies, and generating motor actions. One can see associations at neuronal level as a process in which neuronal sub-self induces mental images inside the postsynaptic neuronal self. Neuron could be seen as a fractally scaled down version of a sensory pathway.

The sensory input of a neuron is determined by the inputs from active pre-synaptic neurons. Postsynaptic receptors are analogs of ordinary sensory receptors and they determine the sensory qualia and primary sensory mental images of the neuron about external world (also ordinary cells have sensory receptors and sensory representations but only about nearby environment). Microtubuli inside dendrites are the analogs of sensory pathways, and cell membrane and cell nucleus could play the role of the neuronal skin and brain. Both could give rise to sensory representations. Sensory representations at the magnetic body of nucleus could be generated by DNA or directly by the communications from cell membrane. Neurons would have sensory qualia and neuronal receptors and receptors at the surface of any cell could give rise to the analogs of tastes and smells. Cells could also see and hear at some wave length ranges and the micro-tubuli associated with the cilia span a length scale range containing visible frequencies.

The general model of how cell membrane acts as a sensory receptor [K38] allows to make this vision much more detailed and also allows to understand how the qualia experienced by us emerge.

1. DNA as topological quantum computer model plus certain simplifying assumption leads to the conclusion that the spectrum of net quantum numbers of quark antiquark pair define the primary qualia assignable to a nucleotide-lipid pair connected by a magnetic flux tube. The most general prediction is that the net quantum numbers of two quark pairs characterize the qualia. In the latter case the qualia would be assigned to a pair of receptor cells.

2. Composite qualia result when one allows the nucleotide-lipid pairs of the membrane to be characterized by a distribution of quark-antiquark pairs. Cell membrane -or at least the axonal parts of neurons- would define a sensory representation in which is a pair of this kind defines a pixel characterized by primary qualia. Cells would be sensory homunculi and DNA defines a sensory hologram of body of or of part of it. Among other things this would give a precise content to the notion of grandma cell.

3. Josephson frequencies of biologically important ions are in one-one correspondence with the qualia and Josephson radiation could re-generate the qualia or map them to different qualia in a one-one and synesthetic manner in the neurons of the sensory pathway. For large values of Planck constant Josephson frequencies are in EEG range so that a direct connection with EEG emerges and Josephson radiation indeed corresponds to both bio-photons and EEG. This would realize the notion of sensory pathway which originally seemed to me a highly non-realistic notion and led to the vision that sensory qualia can be realized only at the level of sensory organs in TGD framework.

4. At the level of brain motor action and sensory perception look like reversals of each other. In zero energy ontology motor action this analogy can be justified so that the model of sensory representations implies also a model for motor action. Magnetic body serves as a sensory canvas where cyclotron transitions induced by Josephson frequencies induce conscious sensory map entangling the points of the magnetic body with brain and body.

11.5.2 Functions Of Nerve Pulse

Nerve pulses inducing generalized motor action represent pushes and pulls in spin glass energy landscape of brain. These pushes and pulls induce motion in the spin glass landscape and generate somehow both neuronal and our emotions. Transmitters mediate nerve pulses from presynaptic neuron to postsynaptic neuron and modify the properties of the synapse and of the postsynaptic neuron. Fast neurotransmitters controlling directly ion channels are involved with the process and the relevant time scale is one millisecond. No long term change of the postsynaptic neuron is involved. Slow neurotransmitters involving second messenger action are involved with the modulation of the response of the postsynaptic neuron, and the time scales can be of order of minutes. In this case the properties of the postsynaptic neuron are changed. Emotional reactions involve typically slow transmitters and their effect can be regarded as a generalized motor action inducing motion of the neuron in the spin glass energy landscape of the neuron.

What the specialization of sensory pathways to sensory modalities means?

Sensory pathways are specialized to produce some specific sensory qualia. How this specialization correlates with what happens at the neuronal level?

1. If one accepts the notion of magnetic body, it is not too difficult to accept the idea that the magnetic bodies associated with the sensory organs are the seats of the sensory representations whereas higher levels of CNS are responsible for symbolic and cognitive representations accompanying sensory representations. TGD based view about long term memories makes it possible to defend this view against standard objections such as phantom limb phenomenon, projected pain, and the stimulation of sensory hallucinations electrically. One cannot exclude the possibility that even the sharing of mental images with the objects of external world contributes to the conscious experience.

2. An almost diametrically opposite view is that qualia are like colors of a map and coloring is decided at quite high level of sensory processing.

These views need not be mutually exclusive. Sensory qualia seated at sensory organs can serve as the colors of the map if sensory receptors and brain form single quantum system in which entanglement with and back projection to the structures defined by sensory receptors is essential. This back projection could transform the primary mental images. This view would also explain the rapid eye movements during REM sleep and oto-acoustic sounds.

In this picture association areas could be seen not as cognitive areas, where sensory input is transformed to cognitive output, but areas in which the mental images associated with various symbolic and cognitive pathways fuse to a single mental image. Therefore the term association would be somewhat misleading. A genuine association can be seen to result when a sub-self wakes up sub-self by nerve pulse patterns and is experienced by a higher level self as two subsequent mental images.

Could nerve pulse patterns realize the memetic code?

TGD based model of cognition allows to construct a model for memetic code in which sequences of 126 cognitive neutrino pairs of total duration of about .1 second correspond to Boolean statements or also integers in the range $\{1, 12^{126}\}$ in binary representation. The model for the physical realization of the memetic code is discussed in more detail in [K47] and here only the basic idea will be described.

The model for the memetic code assumes that antineutrinos resides in the strong Z^0 magnetic field associated with the cell membrane and having the direction of the axon. The antineutrinos have suffered spontaneous Z^0 magnetization. Memetic codons consisting of (almost) 127 bits are realized as temporal sequences of spontaneous Z^0 magnetization of antineutrinos at $k = 151$ cell membrane space-time sheet. The ground state with all bits in the direction of the Z^0 magnetic field does not represent consciously anything so that the number of representable bit sequences is $M_{127} = 2^{127} - 1$ which corresponds to almost 127 bits.

Memetic codons are generated by Z^0 magnetic pulses reversing the direction of local Z^0 magnetization. The magnetic transition frequency is energy difference for states $(n + 1, up)$ and

$(n, down)$ for cognitive antineutrinos of opposite spin in the strong Z^0 magnetic field of the axonal membrane. There is however a "miracle" involved. The magnetic transition frequencies of muonic and tau neutrinos for the transitions between states $(n+1, up)$ and $(n, down)$, are in the range of ELF frequencies and that for the largest possible value of the axonal Z^0 magnetic field this frequency is slightly higher than the maximal frequency of nerve pulses. Hence the duration of nerve pulse implies automatically that it generates harmonic perturbation giving rise to spin flips of neutrinos [K47, K78].

The basic objections against the idea that nerve pulses generate memetic codons are following.

1. The minimum time interval between nerve pulses is slightly longer than required by memetic codon.

2. The prediction would be that high level linguistic cognition is everywhere in brain. Rather, higher level cognition should be associated with the neurons at multi-modal associative regions of cortex [K47] or with cognitive neural pathways leading to these areas. Only humans possess the parietal-occipital-temporal association region combining somatosensory-, visual- and auditory inputs into associations and giving meaning to the objects of the perceptive field. Perhaps the emergence of this associative region associating Boolean statements with sensory features has led to Homo Sapiens.

3. Ordinary nerve pulse patterns suggest strongly frequency coding rather than refined memetic code. In the case of memetic code it would mean roughly 64 nonequivalent codons. This in fact might be enough to understand the basic phonemes of language as expressions of memetic codons.

These arguments suggest that nerve pulse patterns give rise only to a frequency coding such that only the frequency of the bits differing from the standard value is of significance. The intensity of sensory input, motor output, and emotional expression could be coded in this manner. MEs can generate also oscillations of the membrane potential and it is known that this kind of oscillations accompany hearing. These oscillations could also induce reversal of Z^0 magnetization and could allow to realize memetic code in full complexity.

Generation of declarative long term memories at micro-tubular level

The TGD based model of declarative long term memories is based on the mirror mechanism with brain and body effectively serving as time like mirrors from which negative energy MEs are reflected as positive energy MEs. Long term memories would be coded to subjecto-temporal changes of the micro-tubular conformations [K52] which allow a huge number of almost degenerate configurations, and the transitions between these configurations generate MEs with ultra-low frequencies determined by the time span of the long term memory. The natural first guess is that the nerve pulse patterns accompanied by MEs are an essential part of the process of building long term memories by inducing the motion of the axonal micro-tubuli in the spin glass energy landscape. Nerve pulse could be also accompanied by a separate wave propagating along the axonal micro-tubuli and containing much more detailed information about the sensory input specifying the content of declarative long term memories. This would mean huge information storage capacity and also explain why the axonal lengths associated with the sensory pathways are maximized.

A model for the cognitive code associated with with micro-tubuli is discussed in [K67]. The model is based on $13 \times 13 = 169$ bits defined by single full turn for 13 helical tubulin strands consisting of 13 tubulins each. Since only the changes of tubulin conformations contribute to the micro-tubular conscious experience, only $2^{169}-1$ patterns code for conscious experiences. Therefore the code represent only 168 full bits and the remaining almost bit could define some kind of parity bit. The presence of a sufficiently strong external electric field along the micro-tubule would imply that the change of bit is replaced with a pattern of $b \to b+1 \to b$ transitions leading from the ground state to excited state and back to the ground state.

An interesting possibility is that micro-tubuli define a cognitive code above the memetic code in the hierarchy of cognitive codes so that biology would not reduce to neither genetic nor memetic code. The changes of the micro-tubular conformation patterns could be coded to 2^{126}

memetic codons represented by field patterns associated with MEs. The $64 \to 21$ correspondence for DNAs and amino-acids would be generalized to $2^{169} - 1 \to 2^{127} - 1$ correspondence such that 168 full bits would be mapped to 126 full bits. The degeneracy would be $6log(2)/log(21) \simeq 1.39$ for the genetic code and $168/126 = 1.33$ for the micro-tubular code.

11.5.3 Functions Of Transmitters

It is an interesting challenge to try to understand the role of various information molecules, in particular neurotransmitters, in TGD inspired conceptual framework.

Information molecules as quantum links in quantum web?

One particular challenge is to find convincing "reason why's" for what happens in the synaptic contacts. Why myriads of neurotransmitters are needed: inhibition, excitation and neuro-modulation could indeed be carried out in much simpler manner?

1. Information transfer is certainly in question and a natural assumption is that the information is conscious quantum information. If so, it is not the transfer of the neurotransmitter molecules which is essential but the transfer of bound state entanglement of these molecules with the environment and thus of conscious information. This is in accordance with the computer metaphor: neurotransmitters would be like links to different pages in the web activated in the transfer process analogous to sending an email containing a list of links plus text. Also a transfer of usable energy could be involved: the positive energy MEs transferred could provide their energy to the postsynaptic cell unless they are used to energize the transfer process. Besides neural transmitters blood cells and various molecules transmitted by blood and lympha could be carriers of quantum links and hormonal action at the deeper level would be quantum communication in this sense.

2. When information molecules and receptors form a quantum bound state, macro-temporal quantum coherence is generated and this correspond at the level of conscious experience a multi-verse state of "one-ness" and from the point of information processing a quantum computation like process [K52]. One could also see information molecules and receptors as representative of opposite molecular sexes. The resulting non-entropic mental image corresponds to sensory qualia of the neuron analogous to smells and tastes. In principle, each neurotransmitter gives to a distinct neuronal taste or smell. Also neuronal analogs of vision and hearing are possible. Micro-tubuli indeed give rise to infrared vision in the case of bacterial cells.

3. This picture is consistent with the interpretation of neurotransmitter induced experiences as kind of chemical qualia analogous to tastes and odors and giving rise to emotions at our level of self hierarchy.

Excitation and inhibition

Excitation and inhibition are seen as basic functions of neurotransmitters. More precisely, the attribute excitatory/inhibitory can be assigned with a given transmitter-receptor combination. Gardener metaphor states that brain is a gardener allowing particular plants, now mental images having neural firing patterns as neurophysiological correlates, to flourish. One could argue that this kind of selection is reasonable in order to use metabolic resources optimally. One must be however very cautious here. Paradoxically, the metabolism during synchronous firing does not seem to increase [**?**]. This finding has two mutually non-exclusive explanations.

a) Remote metabolism involving the generation of negative energy MEs received by glial cells serving as a storage of metabolic energy is involved.

b) Inhibition could require actually more energy than excitation: neural firing would occur spontaneously when the energy feed to the system is subcritical. At least for the inhibition caused by hyper-polarization this view might make sense. One can say that the gardener would actively prevent the growth of some plants. Inhibition would be censorship preventing a spontaneous generation of mental images in accordance with the vision of Huxley about brain as a filter which

prevents conscious experience rather than creates it. The hypothesis that bio-control is quite generally based on this principle is attractive since it is easier to prevent a complex process to occur spontaneously than to force a complex process to occur in a desired manner.

Option b) would explain several paradoxical looking findings about the correlation of inhibition with the level of self control. The amount of inhibition increases and the behavior becomes more controlled and "civilized" as one climbs up in the evolutionary tree being highest for humans. Inhibition is higher for adults than for children as is also the level of self control. Inhibition is dramatically reduced during the process of physical death. In all these cases the reduced inhibition would naturally correlate with the reduction of the metabolic feed. Inhibition is also reduced during several altered states of consciousness and these states of consciousness involve also a high level of relaxation.

If the reduced inhibition means a reduction of energy feed, a depletion of energy resources is an unavoidable outcome. This leads to a spontaneous generation of negative energy MEs by starving neurons making possible remote entanglement and remote metabolism. In particular, synchronous neural firing would involve also remote metabolism so that option a) is not excluded by b). The generation of episodal long term memories and various kinds of remote mental interactions would be an automatic side product. The memory feats of synesthetics indeed correlate with a dramatic reduction of metabolism in left cortex; various remote mental interactions are reported to occur during altered states of consciousness; and there are reports about the association of telepathy, precognition and poltergeist type phenomena with the physical death of a close relative or intimate friend.

On the other hand, if inhibition means heightened metabolic energy feed, it also reduces the need to generate negative energy MEs. The reduction of entanglement with the environment means among other things fewer shared mental images. Therefore the increase of inhibition would be a correlate for the increasing privacy of conscious experience. Ironically, the physical well-being would more or less unavoidably lead to the alienation and unhappiness suffered by so many members of post-modern society.

11.5.4 Negentropic Entanglement And The Role Of Neurotransmitters

Soon after starting to develop TGD inspired theory of consciousness, I somehow ended up to an email correspondence with Gene Johnson who insistently emailed me links to abstracts about neuroscience. I read the classic Bible about brain by Kandel *et al* [**?**] and tried to make sense of it in my own conceptual framework. This was of course hopeless task since I had only the notions of quantum jump and self. The feeling that something very simple -about which I do not and perhaps cannot ever have a slightest clue- must be behind this incredible complexity made the situation really frustrating. The deeper meaning of EEG, nerve pulse neurotransmitters, hormones- actually of entire brain chemistry and also biochemistry- remained a total mystery.

Development of ideas

After the required number of years however some concrete ideas began to emerge.

1. The notion of magnetic body with fractal onion-like structure meant a decisive step of progress. Also the hierarchy of Planck constants and dark matter as controller of visible matter in living systems emerged. The function of EEG as communication and control tool of magnetic body using biological body as a motor instrument and sensory receptor looked very natural. This led also to a proposal that there is an entire hierarchy of EEGs and their variants. After several trials a vision about nerve pulses as concomitants of quantum level communications emerged as also a vision about DNA as topological quantum computer based on the flux tubes connecting DNA nucleotides with the lipid layers of cell membrane emerged and providing a function for the intronic portions of genome as carriers of quantum computer programs [K2].

2. Also a vision about the biochemical role of dark matter evolved. In particular, phase transitions reducing Planck constant for a magnetic flux tube would induce its contraction and force biomolecules near to each other. This would explain the miracles of DNA replication,

translation, and transcription and quite generally the processes known as aggregation of proteins. The reconnection of magnetic flux tubes changing the topology of the biological Indra's net would be also a central mechanism.

3. The model of nerve pulse and the vision about living matter as a kind of dynamical Indra's net led to a first clear idea about the role of neural transmitters. Transmitters are classified to inhibitory or excitatory depending on whether they increase or reduce the magnitude of the membrane potential. This property is however a property of the receptor rather than that of the transmitter. The same transmitter can have both excitatory and inhibitory receptors although often either receptor type dominates. The proposal was that neural transmitters are associated with the ends of the links of the 4-dimensional web connecting neurons to each other. Neurotransmitter attaches to the plug defined by the receptor connecting the communication wire from presynaptic neuron to the flux tube leading to the passive portion of postsynpatic DNA strand acting as sensory receptor. This would make possible rapid communications to DNA. The corresponding active portion of DNA strand could then respond by generating an activity at the level of cell membrane. This conforms with the general idea that proteins represent only one particular outcome of the gene expression. This left open the question whether the excitatory-inhibitory dichotomy could have some deeper meaning.

4. Also it became clear the emotions and information are closely related and that peptides acting both as neurotransmitters and hormones are crucial for emotions [**?**]. I proposed that emotions are "entropic" qualia. Although I realized the importance of negentropic entanglement I did not have time or I was not able to realize how far reaching this notion actually is.

Is genome a fractal counterpart of brain?

Fractality replaces standard reductionism in TGD Universe. An old idea inspired by p-adic length scale hypothesis is that the binary structures associated with p-adic scales $L(k) \propto 2^{k/2}$ and $L(k+2)$ define a fractal hierarchy. Brain hemispheres would represent one example of this kind of pair, lipid layers ofe cell membrane second one, and DNA double strand third one. Just for fun one could assume that the structure and functions of brain hemispheres have fractal analogs at the level of DNA double strand and vice versa and look what kind of questions this inspires.

1. Could the identical structures of DNA strands correspond to the anatomical similarity of right and left brain and could the functional asymmetry of the strands correspond to the laterizalization of brain function? Could the genome act as the brain of cell? Could various brain areas have counterparts at the level of DNA? Could the hydrogen bonds between nucleotides serve as the counterpart of corpus callosum? Could the splitting of these bonds during transcription and replication correspond to what happens to a split brain patient?

2. Before continuing it must be made clear that the global identification of right-left dichotomy with holistic-reductionistic dichotomy is wrong. One can however consider its local variant with holism and reductionism assigned do the pairs of right and left brain areas. For instance, in contrast to the naïve rule the emotional right (left) brain (amygdala) would be reductionistic (holistic, negentropic) whereas the intellectual right (left) would be holistic (reductionistic, entropic). The practical reason to the division to the entropic and negentropic pieces could relate to the metabolism. The entropic regions could provide the binding energy as a usable energy to the positive energy negentropic entanglement. Good is not possible without Evil! There are no winners without losers! One must be however very cautios in making conclusions since second law might break down for dark matter.

   Right brain is specialized in spatial thinking and left brain to verbal thinking and arithmetics: the geometry-algebra division of mathematics! Right brain is not so good in motor actions as left brain as any right-handed person knows. Right brain is however better in tactile sensing: right handed persons tend to use left hand for touching objects to get an idea about their shape. Also this can be understood in holistic-reductionistic picture.

3. Apart from reflex actions almost all activities of the body seem to be controlled to a high degree by brain. Could also the activitities of cell be regarded as motor actions of the genome

acting as the brain of cell receiving sensory imput from the cell membrane? Could one identify the analogs of sensory areas receiving information from cell membrane, processing, and sending it to the association areas? Could the analogs associative areas be identified as intronic portions of DNA performing topological quantum computations and communicating the outcome to the higher motor areas at the intronic portions of the of the complementary strand, wherefrom they would be communicated to the primary motor areas identifiable as the regions of DNA expressing themselves either chemically (RNA and proteins), as activities generated directly at the level of cell membrane, or electromagnetically? For instance, could neurotransmitter in the receptor generate the feed of sensory input to the genome inducing the change of the membrane potential as the counterpart of motor action. Could prokaryotes without introns be analogous to brain with only primary sensory and motor areas or to mere ladder-like nervous system?

One could argue that the analogy between DNA are brain fails because second DNA strand is completely passive whereas both brain hemispheres express themselves via motor actions. This is not the case! Both DNA strand has regions expressing themselves but the transcription takes place in opposite directions. Hence DNA strands have motor and sensory areas as also brain does, and the natural guess is that primary motor areas correspond to the areas expressing themselves in terms of RNA, proteins, and possibly also as actions at the level of cell membrane. Primary sensory areas would correspond to to regions complementary to the primary motor regions.

4. What right brain sings-left brain talks metaphor could mean in this picture? Pitch-rhythm dichotomy is more technical expression for this dichotomy. Function providing local data and its Fourier transform providing global data is more abstract representation for this dichotomy and Uncertainty Principle for momentum and position relates closely to these two representations of information. This dichotomy could reflect the presence of two different natural time scales and millisecond time scale for nerve pulses and.1 second time scale for moments of sensory experience are the natural candidates.

   If so, this dichotomy could directly reflect the different time scales assignable to u and d type quarks (1 millisecond) and to electron (100 ms) and reduce to the level of elementary particle physics. This dichotomy would also have fractally scaled up variants made possible by the hierarchy of Planck constants. The analog of Fourier transform would be the negentropic un-entanglement of sub-CDs (assignable to quarks) to single mental image inside electron's CD. The analog of function itself would be a collection of sub-CDs representing separate unentangled mental images assignable to individual nerge pulses in millisecond time scale. Also the topological quantum computations assigned to the intronic portions correspond to different time scales due and reflect quark-lepton dichotomy. The quarks in question could be the quarks assigned to the ends of flux tubes in the model of DNA as topological quantum computer.

5. This raises some questions. Could the gene expressions of the two strands somehow reflect this dichotomy? For instance, could the flux tube structures assignable to the amino-acid sequences correspond to the millisecond and 100 ms scales assignable to quarks and electron have the property that also the functioning of these proteins is characterized by these typical time scales? According to [I80] the time scales of protein folding vary from.1 s to 10^3s. According to Wikipedia [I6] the typical time scale is 1 millisecond which suggests that the time scales correspond to two ranges beginning from ms and 100 ms respectively. There are also short proteins for which the folding takes place in microsecond time scales which might relate to the CD of proton.

What can one say about the function of neurotransmitters?

Can one say anything interesting about the function of neurotransmitters if one combines this highly speculative picture- which can be defended only by the belief on fractality as universal principle- with the idea that bound state and negentropic entanglement make possible the fusion of mental images.

1. Suppose that the fusion of neuronal mental images is required to build higher level mental images that we experience. Suppose that neuronal mental images involve DNA in an essential manner. Suppose that magnetic flux tubes serve as correlates for the entanglement so that the transmission of nerve pulse from pre-synaptic neuron to post-synaptic one creates a flux tube connection between neurons possibly extending to the genome of the post-synaptic neuron. The transmitter at the end of flux tube attached to the receptor acting as a plug would build this connection to some part of DNA specialized to receive particular kind of sensory data from a particular region of cell membrane with complementary strand activating as a response a motor function inducing gene expression at cell membrane level. Gene expression as build-up of proteins would not be necessary and is also too slow for neural activities.

2. Suppose that the entanglement between neurons generated in this process is always negentropic as the interpretation as the idea about neural correlate for a conscious association suggests. One could also ask whether the neurons could entangled entropically and whether the entropic-inhibitory association could make sense. This does not lead to anything interesting and entropic entanglement between neurons should be regarded as a pathological condition. Note that neuron-neuron entanglement would be naturally time-like and in this case only negentropic entanglement might be meaningful.

   (a) To gain some perspective consider the activation of cell in general by some external perturbation from the resting state to the active state (here I have learned a lot from email correspondence with Vladimir Mateev) In the resting state the proteins inside cell are passive -or rather, forced to be passive- as one might expect on basis of the general vision about homeostasis. The unfolded proteins and unfolded portions of the folded proteins are connected by hydrogen bonds to ordered water so that the folding occurring otherwise spontaneously is prevented. One can say that the cellular winter prevails. The situation is however nearly critical and if external perturbation occurs cell liberates metabolic energy melting the ice and spring comes. Also the outer surfaces of globular proteins are hydrogen bonded and when the ordered water melts, spontaneous melting of the protein takes place leading to a partial unfolding.

   The resulting folded proteins and partially unfolded globular proteins interact by forming aggregates and this activity would naturally involve $\hbar$ reducing phase transitions and flux tube reconnections. In TGD based model the mechanism of both folding and melting would be the liberation of metabolic energy destroying the hydrogen bonds and the energy for this comes from the ATP containing positive energy negentropic bond between O=s of phosphates.

   (b) Similar situation could prevail at the cell membrane. One can imagine that cell membrane is like a particle at the bottom of a small potential well. At the other side there is a deep well representing the generation of nerve pulse and at the other side a high wall corresponding to hyper-polarization requiring energy. Both polarization and hyper-polarization are prevented by the freezing of protein activities needed to induce them. The flux tubes connecting the presynaptic neuron and receptor and possibly genome are always negentropic and their formation can as such serve as the signal leading to the partial melting of the ordered water making possible to generate action leading to either de-polarization or hyper-polarization. The signal could be just the additional metabolic energy making it possible for these transitions to occur.

   (c) This picture does not require any communications from the receptor to the genome and in the simplest situation the resulting action could be seen as the analog of reflex action. These communications could of course be present and the negentropic entanglement could make it easier to induce de-polarization also now. Also the question whether excitatory-inhibitory dichotomy for the receptors has some deeper meaning apart from taking the neuron nearer to or farther from criticality for firing remains unanswered.

11.6 Relating The Model Of Nerve Pulse With The Micro-Tubular Level

The relationship of the presumed quantum dynamics of the cell interior to the nerve pulse is the basic topic of quantum consciousness theories. Micro-tubular conformational dynamics; gel-sol phase transition of the cytoplasmic water inducing the de-polymerization of the actin polymers; the parallelization of micro-tubuli possibly making possible a coherent generation of infrared em radiation; and Mg^{+2} and Ca^{+2} ions as controllers of polymer stability, are some of the most important pieces of the jigsaw. The hierarchical model of Alex Kaivarainen emphasizing these aspects provided crucial pieces of information [**?**] allowing to construct many-sheeted view about this process. The hierarchy of condensed matter excitations introduced by Kaivarainen corresponds in TGD framework to the hierarchy of space-time sheets whereas the molecular Bose-Einstein condensates of Kaivarainen correspond to BE condensates of various bosonic ions and Cooper pairs at various cold space-time sheets. The classical article of Nanopoulos summarizing basic facts and various ideas about micro-tubuli [**?**] has been a continual source of information and inspiration and is warmly recommended.

One important element are negative energy IR MEs having phase conjugate laser beams [D3] as physical counterparts. First of all, they make possible intentional action at the micro-tubular level: even the TGD based model of mRNA-protein translation involves intentional aspects. Negative energy MEs are crucial for the understanding of the macro-temporal quantum coherence and have inspired the notions of remote metabolism and quantum credit card. The notion also leads to what might be called seesaw mechanism of energy metabolism, and allows to understand how micro-tubular surfaces provide dynamical records for the cellular sol-gel transitions and thus define fundamental micro-tubular representation of declarative long term memories.

The vision about dark matter hierarchy brings in perhaps the most decisive new elements.

1. Dark matter hierarchy leads to the identification of big leaps of evolution in terms of the emergence of new levels of dark matter hierarchy. Magnetic bodies are the intentional agents in this picture and it is possible to understand the control of logistics and declarative memory as basic functions associated with micro-tubules.

2. Synchronous neuron firing involves parallelization of microtubules. This coherent action can be understood in terms of macroscopic quantum coherence realized in terms of super-genes and the more general notion of multi-neuron with neurons organized to linear structures analogous to the lines of text on the pages of book defined by magnetic flux sheets.

3. Ca^{+2} and Mg^{+2} ions are known to be important for the de-polymerization of microtubules and actin molecules occurring during nerve pulse. This conforms with the central role of the Bose-Einstein condensates of dark bosonic ions Ca^{+2} and Mg^{+2} and their exotically ionized counterparts in the generation of pulse in the proposed model, and more generally, in quantum bio-control based on charge entanglement between cell and magnetic body.

4. The ordered water associated with gel phase was earlier modelled in terms of dropping of protons to $k = 139$ space-time sheets. In the new framework this phase can be identified as a partially dark water. The response of cells to IR radiation is maximal at photon energy.1 eV. What makes bells ringing is that the model of high T_c conductivity based on dark matter hierarchy leads to the identification of the cell membrane as a Josephson junction generating ordinary IR photons with energy $2eV = .1$ eV at the membrane potential corresponding to threshold for nerve pulse generation kicking protons to $k = 139$ space-time sheet associated with ordered water.

   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. In the following only the "dropping" option is discussed.

This section was written much before the breakthrough induced by the model of DNA as TQC and the inspiration coming from the model of nerve pulse as acoustic soliton by Danish researchers [**?**]. Hence a lot is lacking and the contents of section are not necessarily completely consistent with the new vision. For instance, the phase transitions changing the value of $\hbar$ and TQC using 4-colored braids provide a general explanation for the selectivity of the catalytic action [K2]. I have however decided to leave the section as it is.

11.6.1 Dark Matter Hierarchy And Big Leaps In Evolution

Dark matter hierarchy leads to an amazingly concrete picture about evolutionary hierarchy allowing to identify the counterparts for concepts like mineral, plant, and animal kingdom that we learned during schooldays and ceased to take seriously as students of theoretical physics as we learned that other sciences are just taxonomy. Even more, a view about what distinguishes between prokaryotes, eukaryotes, animal cells, neurons, EEG, and even about what makes cultural evolution, becomes possible. This view is also very useful when one tries to understand the role of microtubules.

The appearance of CDs scaled up in size by $r = \hbar/\hbar_0$ and space-time sheets scaled up in size by $\sqrt{r}$ means the emergence of new levels of structure and it is natural to identify big leaps in evolution in terms of emergence of new larger matter carrying space-time sheet magnetic flux sheets and corresponding magnetic bodies. If magnetic flux quanta are scaled by r magnetic flux quantization conditions remain unaffected if magnetic field strengths scale down by $1/r$ so that the energies of cyclotron photons are not affected. The thickness of flux tubes can remain unchanged if the currents running at the boundaries of the flux quantum cancel the magnetic flux. As already found, this mechanism must be at work inside living organisms whereas in far away region flux quanta are scaled up in size.

The attractive hypothesis is that the leaps in evolution correspond to the emergence of dark variants of weak and possibly also color interactions in dark p-adic length scales which correspond to ordinary p-adic length scales characterized by Mersenne primes. These leaps would be quantum leaps but in different sense as thought usually. The emergence of higher dark matter levels would basically mean the integration of existing structures to larger structures. A good metaphor are text lines at the pages of book formed by magnetic flux sheets whose width is scaled up by r as the new level of dark matter hierarchy emerges. The big leaps can occur both at the level of organism and population and organisms with rather low individual dark matter level can form societies with high dark matter levels and high collective intelligence (honeybees and ants are good example in this respect).

Certainly also other scalings of Planck constant than those summarized in tables are possible but these scalings are of primary interest. This intuition is supported by the observation that electron is completely exceptional in this framework. Electron's dark p-adic length scales corresponds to p-adic length scales $L(k)$, $k = 167, 169$, assignable to atomic and molecular physics and to the Gaussian Mersennes $M_{G,k} = (1+i)^k - 1$, $k \in \{151, 157, 163, 167\}$, assignable to the length scale range between cell membrane thickness 10 nm and nucleus size 2.58 μm. The corresponding p-adic length scales, the number of which is 23, are excellent candidates for the scales of basic building bricks of living matter and vary from electron's p-adic length scale up to 1.25 m ($k = 167$ defining the largest Gaussian Mersenne in cell length scale range) and defining the size scale of human body. The corresponding p-adic time scales are also highly interesting and vary from.1 seconds for electron defining the fundamental biorhythm to 9.6×10^{14} years which is by 4-5 orders longer than the age of the observed Universe. For $k = 167$ the time scale is 1.1×10^{11} years and is by one order of magnitude longer than the age of the observed Universe estimated to be 1.37×10^{10} years [E1].

This conceptual framework gives rather strong guidelines for the identification of the levels of evolutionary hierarchy in terms of dark matter hierarchy. The outcome is a more detailed vision about big evolutionary leaps. Note that in the sequel only the general option is considered: the justification for this is that for this option electron appears as a dark particle for all length scales defined by Gaussian Mersennes as well as in atomic length scales. The basic vision in nutshell is that evolution means the emergence of dark weak and gluonic physics in both dark and ordinary length scales and that the size scales of the basic biostructures correspond to Mersenne primes and their Gaussian variants.

A sketch about basic steps in evolution

The vision about evolution depends on what one assumes about the initial state.

1. If one assumes that weak bosons with ordinary value of Planck constant were present in the beginning, evolution would mean a steady growth of k_d. Note that the hypothesis is $h_{eff} = nh$, where n is product of distinct Fermat primes and power 2^{k_d}. The problem is that small values of $k_d = k_1 - k_2$ correspond to the Gaussian Mersennes defining cellular length scales. If these exotic weak physics were present from the beginning, large parity breaking in cellular length scales would have been present all the time.

2. An alternative and perhaps more realistic view is that the evolution means the emergence of exotic weak physics corresponding almost vacuum extremals in increasingly longer length scales. A possible mechanism could have been the induction of exotic $\hbar_0$ variant of weak physics at the nearest Mersenne length scale k_{next} by the dark variant of weak physics at level k so that one would have $k_d = k_{next} - k$. The simplest induction sequence would have been $89 \to 107 \to 113 \to 127 \to 151 \to 157 \to 163 \to 167$ corresponding to $k_d \in \{18, 6, 14, 24, 6, 6, 4\}$. A possible interpretation of exotic $\hbar_0$ physics is in terms of almost vacuum extremals and non-standard value of Weinberg angle: also weak bosons of this physics would be light. This sequence defines the minimal values for k_d but also larger values of k_d are possible and would correspond to steps between neighbours which are not nearest ones.

The following sketch about the basic steps of evolution relies on the latter option.

1. Elementary particle level

Magnetic bodies with size scale defined by the sizes of CDs assignable to quarks and leptons and possibly also weak bosons (already now the size of big neuron emerges) corresponds to the lowest level of hierarchy with the sizes of the basic material structures corresponding to the Compton lengths of elementary particles. The fundamental bio-rhythms corresponding to frequencies 10, 160, and 1280 Hz appear already at this level in zero energy ontology which suggests that elementary particles play a central and hitherto unknown role in the functioning of living matter.

2. $89 \to 107$ *step with* $k_d = 18$

The first step would have been the emergence of $k_{eff} = 107$ weak bosons inducing $\hbar_0$ weak physics in $k = 107$ length scale characterizing also ordinary hadrons. This in turn would have led to the emergence of exotic nucleons possibly corresponding to almost vacuum extremals. The reduction of the model for the vertebrate genetic code to dark hadron physics [K108] is one of the most unexpected predictions of quantum TGD and assumes the existence of exotic- possibly dark- nucleons whose states with a given charge correspond to DNA, RNA, mRNA, and tRNA. The $\hbar_0$ variants of these nucleons would interact via weak bosons with hadronic mass scale. The exotic variants of the ordinary $k = 113$ nuclei would correspond to the nuclear strings consisting of exotic nucleons [K30, K108] and define nuclear counterparts for DNA sequences. Their dark counterparts could define counterparts of DNA sequences in atomic physics length scales. Therefore a justification for the previous observation that genetic code could be realized at the level of hadron physics and that chemical realization would be higher level realization finds justification. The anomalous properties of water could be also partly due to the presence of dark nucleons and the proposal was that the presence of exotic nuclei is involved with water memory [K49]. The possible existence of the analog of DNA-RNA transcription between ordinary DNA and its nuclear counterpart would have dramatic implications. For instance, one can imagine a mechanism of homeopathy based on this kind of transcription process which would also allow a modification of genome by using dark nuclei to communicate the DNA sequences through the cell membrane to the target nuclei.

3. $107 \to 113$ *step with* $k_d = 6$

The next step would have been the emergence of $k_{eff} = 113$ weak bosons inducing $\hbar_0$ weak physics in $k = 113$ length scale characterizing also ordinary hadrons. Exotic variants of the ordinary nuclei possibly corresponding to almost vacuum extremals could have emerged interacting weakly (or actually relatively strongly!) via the exchange of weak bosons with mass scale of order

100 MeV. Also dark variants of the exotic $k = 107$ nucleons could have have emerged and formed exotic nuclei of size scale $k = 119$.

4. $113 \to 127$ *step with* $k_d = 14$

At this step weak bosons in electron mass scale would have emerged. Whether these weak bosons could have induced large parity breakings in atomic and molecular length scales is not clear. Viruses, which do not yet possess cell membrane could correspond to this level of hierarchy.

5. $127 \to 151$ *step with* $k_d = 24$

This step would have been fundamental since weak bosons in cell membrane length scale would have appeared. Note that by $113 - 89 = 24$ this step also leads from $k = 89$ weak bosons to $k = 113$ weak bosons. The weak bosons assignal to $k = 151$ could correspond to the weak interactions associated with almost vacuum extremals and $sin^2(\theta_W) = .0295$ could correspond to the weak physics in question.

$k_d = 24$ step for $k = 113$ $\hbar_0$ weak bosons would have produced them in $k_{eff} = 137$ atomic length scale with $L(137) \simeq .78$ Angstrom This could have naturally led to large parity breaking effects and chiral selection.

Dark $k_{eff} = 151$ electrons appearing in the TGD inspired model of high T_c super-conductivity would have been a by-product of this step. Whether dark electrons could have transformed to light $\hbar_0$ electrons (of mass.25 keV) with a common mass scale of order 10^2 eV with exotic weak bosons is an interesting question. The model of high T_c super-conductivity predicts the presence of structures analogous to cell membrane. This would suggest that cell membranes emerged and chiral selection emerged at this step so that one could not distinguish the emergence of molecular life as a precedessor for the emergence of cell membrane like structures. This would conform with the fact that DNA molecules are stable only inside cell nucleus. Note that for $k_{eff} = 151$ electron's CD has time scale $2^{24} \times .1$ seconds -that is 19.419 days (day=24 hours).

The smallest nanobes [I4] appearing in rocks have size 20 nm and could have emerged at this step. The size of the viruses [I8] is between 10-300 nm covers the entire range of length scales assignable to Gaussian Mersennes, which suggests that smallest viruses could have emerged at this step. Also the smallest [I3] [I3], which by definition have size smaller than 300 nm could have appeared at this stage.

6. The remaining steps

The remaining steps $k = 151 \to 157 \to 163 \to 167$ could relate to the emergence of coiling structure DNA and other structures inside cell nucleus. $k = 167$ would correspond to $k_d = 167 - 89 = 68$ to be compared with the value $k_d = 47$ required by 5 Hz Josephson frequency for the neuronal membrane for -70 mV resting potential. Note that $k_d = 48$ (state 1-2 of deep sleep) corresponds to $k = 163$.

By their smallness also double and triple steps defined by $k_d = k_{i+n} - k_i$, $n > 1$, are expected to be probable. As a consequence, electrons can appear as dark electrons at all the Gaussian Mersenne levels. At these steps the dark electrons corresponding to primes $k_{eff} = 137, 139$ would appear. For $k = 137$ dark electron appears with CD time scale equal to 128 seconds- rather precisely two minutes. The model for EEG suggests that the exotic weak bosons appear in the scales $k_{eff} = 136, 137, 138$.

Further multisteps from the lower levels of hierarchy would give structures with size scales above the size of cell nucleus possibly assignable to organs and structural units of brain. The dark levels assignable to electron are expected to be of special interest. It is encouraging that the longest scale assignable to electron in this manner corresponds to $k = 205$ and length scale of 1.28 m defining body size. As a consequence dark electrons are predicted at levels $k = 137, 139, 141, 143, 145, 147$ coming as octaves.

Prokaryotic cells (bacteria, archea) without cell nucleus for which cell membrane is responsible for metabolic functions and genome is scattered around the cell could have emerged at this step. This would mean that the emergence of the cell membrane thickness as a fundamental scale is not enough: also the size scale of membrane must appear as p-adic length scale. The sizes of most prokaryotes vary between 1 μm and 10 μm: the lower bound would require $k = 163$. There also prokaryotes with sizes between.2 μm ($k = 157$ corresponds to.08 μm) and 750 μm. Cell nuclei, mitochondria, and other membrane bounded cell nuclei would have evolved from prokaryotes

in this framework. The sizes of eukaryote cells are above 10 μm and the fact that multicellular organisms are in question strongly suggests that the higher multisteps giving rise to weak bosons and dark electrons in length scales above $L(167)$ are responsible for multi-cellular structures.

This scenario leaves a lot of questions unanswered. In particular, one should understand in more detail the weak physics at various length scales as well as various exotic nuclear physics defined by dark nucleons and dark variants of nuclei.

Division of the evolution to that of biological body and magnetic body

Electron's Mersenne prime M_{127} is the highest Mersenne prime, which does not correspond to a completely super-astrophysical p-adic length scale. In the case of Gaussian Mersennes $M_{G,k}$ one has besides those defined by k in $\{113, 151, 157, 163, 167, \}$ also the ones defined by k in $\{239, 241, 283, 353, 367, 379, 457, 997\}$ [A1]. The appropriately extended model for evolution allows to distinguish between three kinds of values of k_{eff}.

1. The values of k_{eff} for which electron can appear as dark particle and thus satisfying $k_{eff} \leq 205$ (Table 5). These levels would correspond to structures with size below 1.25 m defined roughly by human body size and it is natural to assign the evolution of super-nuclear structures to the levels $167 < k_{eff} \leq 205$.

2. The values of of k_{eff} for which dark gauge bosons are possible in the model. This gives the condition $k_{eff} \leq 235$. These levels correspond to structures in the range 1.25 m-40 km. The identification as parts of the magnetic body can be considered.

3. The values of k_{eff} obtained by adding to the system also the Gaussian Mersenne pair $k \in \{239, 241\}$ allowing also the dark electrons. The lower size scale for these structures is 640 km.

4. The higher levels corresponding to k_{eff} in $\{283, 353, 367, ...\}$. The lower size scale for these structures is 3 AU (AU is the distance from Earth to Sun).

$k_{eff} > 205$ levels would correspond to the emergence of structures having typically size larger than that of the biological body and not directly visible as biological evolution. This evolution could be hidden neuronal evolution meaning the emergence of extremely low Josephson frequencies of the neurons modulating higher frequency patterns and being also responsible for the communication of long term memories.

Biological evolution

In principle the proposed model allowing multisteps between hierarchy levels defined by Mersenne primes and their Gaussian counterparts could explain the size scales of the basic structures below the size scale 1.25 m identified in terms of the $k_{eff} \leq 205$ levels of the hierarchy.

1. The emergence of cells having organelles

The appearance of the structures with $k_{eff} > 167$ (possibly idetifiable as magnetic body parts) should correlate with the emergence of simple eukaryotic cells and organisms, in particular plant cells for which size is larger than 10 μm, which could correspond to $k_{eff} = 171$ for electron and dark variants of weak gauge bosons. $k_{eff} = 177$ is the next dark electron level and corresponds to 80 μm scale. It seems natural to assume that these dark weak bosons do not transform to their $\hbar_0$ counterparts at these space-time sheets.

Cell nucleus would be the brain of the cell, mitochondria would be the energy plant, and centrioles generating microtubules would define the logistic system. Also other organelles such as Golgi apparatus, ribosomes, lysosomes, endoplasmic reticulum, and vacuoles would be present. These organelles would live in symbiosis by topologically condensing to $k_{eff} \geq 171$ magnetic body controlling their collective behavior. Centrosomes associated with animal cells would not be present yet but microtubule organizing centers would already be there.

The recent observations show that centrioles are not always in the characteristic T shaped conformation. Daughter centrioles resulting during the replication of mother centriole use first ours of their lifetime to roam around the cell before becoming mature to replicate. A possible

interpretation is that they are also life forms and that magnetic body utilizes daughter centrioles to perform some control functions crucial for the future development of the cell. For instance, centrioles visit the place where axonal growth in neurons starts.

Cytoskeleton would act as a counterpart of a central nervous system besides being responsible for various logistic functions such as transfer of proteins along microtobuli. Centrioles give also rise to basal bodies and corresponding cilia/flagella used by simple cells to move or control movement of air or liquid past them. Centriole pair would be also used by the magnetic body to control cell division.

The logistic functions are the most obvious functions of microtubules. Magnetic body would control cell membrane via signals sent through the cell nucleus and communicated to the cell membrane along microtubuli. Basal bodies below the cell membrane and corresponding cilia/flagella would serve as motor organs making possible cell motion. Tubulin conformations representing bits would allow microtubule surface to represent the instructions of the magnetic body communicated via via cell nucleus to various proteins moving along the microtubular surface so that they could perform their functions.

TGD based view about long memory recall as communication with geometric past allows also the realization of cellular declarative memories in terms of the conformational patterns. Memory recall corresponds to a communication with geometric past using phase conjugate bosons with negative energies reflected back as positive energy bosons and thus representing an "image" of microtubular conformation just like ordinary reflected light represents ordinary physical object. There would be no need for a static memory storage which in TGD framework would mean taking again and again a new copy of the same file.

Receptor proteins would communicate cell level sensory input to the magnetic body via MEs parallel to magnetic flux tubes connecting them to the magnetic body. We ourselves would be in an abstract sense fractally scaled up counterparts of receptor proteins and associated with dark matter iono-lito Josephson junction connecting the parts of magnetosphere below litosphere and above magnetosphere. The communication would be based on Josephson radiation consisting of photons, weak bosons, and gluons defining the counterpart of EEG associated with the level of the dark matter hierarchy in question.

3. The emergence of organs and animals

The emergence of magnetic bodies with k_{eff} in the range $(177, 181, 183, 187, 189, 195, 201, 205)$ allowing both dark electron and weak bosons could accompany the emergence of multicellular animals. Magnetic body at this level could give rise to super-genome making possible genetic coding of organs not yet possessed by plant cells separated by walls from each other. The super structures formed from centrosomes and corresponding microtubuli make possible complex patterns of motion requiring quantum coherence in the scale of organs as well as memories about them at the level of organs.

4. The emergence of nervous system

k_{eff} in the range $(187, 189, 195, 201, 205)$ allowing dark electrons and weak bosons gives size scales $(.25, .5, 4, 32, 128)$ cm, which could correspond to the scales of basic units of central nervous system. What would be of special interest would be the possibility of charged entanglement based on classical W fields in macroscopic length scales. The emergence of the new level means also the integration of axonal microtobuli to "text lines" at the magnetic flux sheets making possible logistic control at the multineuronal level. The conformational patterns of the microtubular surface would code nerve pulse patterns to bit patterns representing declarative long term memories. An interesting question is whether the reverse coding occurs during memory recall.

The evolution of magnetic body

For mammals with body size below 1.25 m the levels $k_{eff} > 205$ cannot correspond to biological body and the identification in terms of magnetic body is suggestive. The identification of EEG in terms of Josephson frequencies suggests the assignment of EEG with these levels.

1. The emergence of EEG

EEG in the standard sense of the word is possessed only by vertebrates and one should

understand why this is the case. The value of Josephson frequency equal to 5 Hz requires only $k_d = 47$ so that something else must be involved. A possible explanation in the framework of the proposed model comes from the following observations.

1. Besides the maximal p-adic scale $k = 205$ for which electron and weak bosons appears as dark variants the model allows also levels at which only gauge bosons appear as dark particles. From Table 9 one finds that levels $k \in \{207, 211, 213, 217, 219, 221, 223, 225, 229, 235\}$ are allowed. Could it be that these levels and possibly some highest levels containing both electrons and gauge bosons as dark particles are a prerequisite for EEG as we define it. Its variants at higher frequency scales would be present also for invertebrates. The lowest Josephson frequency coded by the largest value of $\hbar$ in the cell membrane system determins the Josephson frequency.

2. The membrane potentials -55 mV (criticality against firing) correspond to ionic Josephson energies somewhat above 2 eV energy ((2.20, 2.74, 3.07, 2.31) eV, see **Table 11.4**). For 2 eV the wavelength 620 nm is near to $L(163) = 640$ nm. Therefore the Josephson energies of ions can correspond to the p-adic length scale $k = 163$ if one assumes that a given p-adic mass scale corresponds to masses half octave above the p-adic mass scale so that the opposite would hold true at space-time level by Uncertainty Principle. Josephson frequencies $f_J \in \{5, 10, 20, 40, 80, 160\}$ Hz correspond to $k_d \in \{47, 46, 45, 44, 43, 42\}$ giving $k_{eff} \in \{210, 209, 208, 207, 206, 205\}$.

   (a) Cerebellar resonance frequency 160 Hz would correspond to $k = 205$ -the highest level for for which model allows dark electrons (also 200 Hz resonance frequency can be understood since several ions are involved and membrane potential can vary).

   (b) The 80 Hz resonance frequency of retina would correspond to $k_{eff} = 206$ -for this level dark electrons would not be present anymore.

   (c) 40 Hz thalamocortical frequency would correspond to $k_{eff} = 207$.

   (d) For EKG frequencies are EEG frequencies below 20 Hz 12.5 and heart beat corresponds to .6-1.2 second cycle (the average.8 s corresponds to $k_{eff} = 212$).

3. Even values of k_{eff} are not predicted by the model based on Mersenne primes allowing only odd values of k_{eff} so that the model does not seem to be the whole truth. The conclusion which however suggests itself strongly is that EEG and its variants identified as something in the range 1-100 Hz, are associated with the levels in at which only dark weak bosons are possible in the proposed model. Note that the size scales involved with EEG would be above the size scale of human body so that we would have some kind of continuation of the biological body to be distinguished from the magnetic body. The time scales assignable to the dark CDs would be huge: for instance, $k = 205$ would correspond to $T = 2^{42} \times .1$s making about 1395 years for electron.

2. Does magnetic body correspond to the space-time sheets carrying dark weak bosons?

The layers of the magnetic body relevant for EEG have have size of order Earth size. Natural time scale for the moment of sensory consciousness is measured as a fraction of second and the basic building blocks of our sensory experience corresponds to a fundamental period of.1 seconds. This scale appears already at $\hbar_0$ level for electron CD. The natural question concerns the relationship of the magnetic body to the $k > 205$ space-time sheets carrying only gauge bosons in the model and having size scale larger than that of biological body. Do they correspond to an extension of biological body or should they be regarded as parts of the magnetic body? The following observations suggest that they could correspond to layers of the magnetic body responsible for the fractal variant of EEG.

1. The primary p-adic time scales (Compton times) $T(239)$ and $T(241)$ correspond to frequencies, which are $2^{\pm 1/2}$ kHz. The geometric average $k = 240$ corresponds to kHz frequency. Is the appearance of kHz scale a mere accident or do the frequencies assignable to the quark CDs correspond to Compton times $\propto \sqrt{2^{k_{eff}/2}}$?

k_d	f_1/Hz	f_2/Hz	f_3/Hz
0	707	1000	1412
4	177	250	354
6	89	1250	177
10	22.1	31.3	44.2
12	11.1	15.6	22.1
14	5.5	7.8	11.1
16	2.8	3.9	5.5
18	1.4	2.0	2.8
20	0.7	1.0	1.4
24	0.2	0.2	0.3

Table 11.4: The Compton frequencies obtained by scaling $2^{k_d/2}$ from the basic triplet $k_{eff} = (239, 240, 241)$. The values of k_d correspond to those predicted by the model based on Mersenne primes.

2. One can apply scalings by 2^{k_d} to the triplet $(239, 240, 241)$ to get a triplet $(239 + k_d, 240 + k_d, 241 + k_d)$. The results are summarized in **Table 11.4**. Clearly the frequencies in question cover also the EEG range. Note that these frequencies scale as $\sqrt{1/r}$ whereas Josephson frequencies scale as $1/r$.

Also ZEG and WEG would appear but in much shorter scales dictated by k_{eff} and might accompany EEG. Somehow it seems that the effective masslessness of weak bosons below given scale is highly relevant for life. One can of course ask whether some larger Gaussian Mersenne could change the situation. There is a large gap in the distribution of Gaussian Mersennes after $k = 167$ and the next ones correspond to $M_{G,k}$, with k in $(239, 241, 283, 353, 367, 379, 457, 997)$ [A1]. The twin pair $k = (239, 241)$ corresponds to a length scales $(1.6, 3.2) \times 10^2$ km and the minimum value for k_d are (72, 74) ($167 \to (239, 241)$ transition).

3. Long term memory and ultralow Josephson frequencies

What determines the time scale associated with long term memory is a crucial question if one really wants to understand the basic aspects of consciousness.

1. Does the time scale correspond to the size scale of CD assignable to electron scaled by $r = \hbar/\hbar_0$? In this case relatively small values of r would be enough and $r = 2^{47}$ would give time scale of 10^{13} s for for electron's CD, which is about 3×10^5 years. This does not make sense.

2. Does Josephson frequency define the relevant time scale? In this case the long term memory would require the analog of EEG in the time scale of memory span. $k_{eff} = 205$ would give 6 ms time scale for memory from the assignment of $k_{eff} = 163$ to the Josephson photons at V=-50 mV implying $k_d = 42$. Minute scale would require $k_{eff} = 217$. The highest level $k_{eff} = 235$ allowed by the model involving only Gaussian Mersennes with $k \leq 167$ would correspond to a time scale of 77.67 days (day is 24 hours). For Gaussian Mersennes defined by $k_{eff} = (239, 241)$ the time scales become about (41.4, 82.8) months (3.4 and 6.8 years). These scales should also define important biorhythms. The claimed 7 years rhythm of human life could relate to the latter rhythm: note that the precise value of the period depends on the membrane potential and thus varies. The presence of the scaled up variants of the by $k_d \leq 78$ allows longer time spans of long term memory and the scaling defined by $k_d = 167 - 163 = 4$ scales up the span of long term memories to (54.4, 108.8) years.

4. Cultural evolution

Higher levels in the hierarchy would correspond mostly to the evolution of hyper-genome coding for culture and social structures. Introns are good candidate for the nucleotides involved. The development of speech faculty is certainly a necessary prerequisite for this break-

through. Already EEG seems to correspond to dark layers of biological body larger than biological body so that one can cask whether the weak bosons and dark electrons in the length scales $k = 239, 241, 283, 353, 367, ...$ could be relevant for the collective aspect of consciousness and cultural evolution. Maybe the size scales $(175, 330)$ km and their scaled up variants by $k_d \leq 78$ might have something to do with the spatial scale of some typical social structure (not city: the area of New York is only 790 km^2).

11.6.2 Some TGD Inspired New Ideas About Biochemistry

TGD provides several new physics concepts whose role in biochemistry is now relatively well understood thanks to the insights provided by the construction of the model of pre-biotic evolution [K42, K43]. Hence there are hopes of understanding the basic principles of cellular control at macromolecular level, and to apply these principles to understand what happens during nerve pulse in the interior of neuron. It is not possible to overestimate the importance of the fact that p-adic length scale hypothesis makes the model quantitative and reduces the number of alternatives dramatically.

Increments of zero point kinetic energies as universal metabolic currencies

The protons and also various other ions and possibly even electrons liberate their zero point kinetic energy while dropping to larger space-time sheets. This process and its reversal define metabolism as a universal process present already during the pre-biotic evolution rather than as an outcome of a long molecular evolution [K42, K43]. ATP-ADP transformation, polymerization by dehydration, and its reversal are key examples of the many-sheeted dynamics involving the dropping of protons from $k = 137$ space-time sheet liberating about.4-.5 eV of zero point kinetic energy and the reversal of this process. In TGD framework metabolism generalizes to a fractal metabolism involving a large number of metabolic currencies.

Negative energy MEs make possible remote metabolism realizing what might called quantum credit card. This makes energetic economy extremely flexible. F-actin polymerization [**?**] is an interesting application of this notion.

1. Each G-actin unit of F-actin is stabilized by Ca^{+2} ion and contains one ATP molecule. The polymerization of G-actin molecule is accompanied by an ATP-ADP transformation involving the dropping of a proton to a larger space-time sheet.

2. The fact that F-actin polymerization does not require energy [**?**] suggests that the zero point kinetic energy liberated in this manner is used to kick one proton to an atomic space-time sheet in G-actin molecule needed in dehydration inducing the polymerization.

3. This is achieved if the G-actin molecule emits a $.4-.5$ eV negative energy photon inducing the hopping of proton to an atomic space-time sheet associated with G-actin. The negative energy photon is received by the ATP molecule and induces the dropping of proton from atomic space-time sheet associated with the ATP molecule. This energetic seesaw could be controlled by a precisely targeted intentional action of the G-actin molecule by the generation of p-adic ME transformed then to negative energy ME. The seesaw mechanism can be generalized to a mechanism controlling the occurrence of sol-gel transitions.

A natural guess is that the emergence of larger space-time sheet with sizes characterized by p-adic length scales is a correlate for the evolution of more refined control and information processing structures utilizing smaller energy currencies. The situation is essentially quantal: the longer the length scale, the smaller the quantum of the metabolic energy. Micro-tubuli and other intracellular organelles represent excellent candidates for this kind of higher level metabolism refining the standard metabolism based on.4-.5 eV energy currency.

Since negative energy MEs with energies above thermal energy scale cannot induce transitions to lower energy states, a good guess is that negative energy MEs corresponding to metabolic currencies above the thermal energy $T_{room} \sim .03$ eV can be utilized for entanglement purposes. This is only a rough rule of thumb since the energy spectrum of systems at a given space-time sheet is expected to have an energy gap. Therefore negative energy MEs, even those below the ELF frequency range, are expected to be important.

Allowing n-ary p-adic length scales, this would mean in the case of hydrogen atom the upper upper bound $L(3,47)\backslash = "L(141) = 2L(139)$ for the p-adic length scales in the hierarchy of water clusters. For electron the upper bound is cell membrane thickness $L(151) \simeq 10$ nm, which corresponds to the effective axonal electronic super-conductivity with the metabolic currency $.025 - .03$ eV. Interestingly, the water at room temperature contains flickering structures of size of order 20-30 nm with lifetime of order.1 ns [D11]. MEs at energy $\simeq .03$ eV could stabilize these structures by kicking the dropped Cooper pairs back to k=151 space-time sheets. One can also ask whether micro-wave MEs at GHz frequency, perhaps generated in the rotational transitions of water molecules, modulate the generation of .03 eV MEs and are thus responsible for the flickering.

Liquid crystal phase of water as a stabilizer of biopolymers

The second key element is the understanding of the role of the liquid [F8] [D1] water in the stabilization of various bio-polymers. The reason is that the water molecules making possible de-polymerization by hydration (also other means, say by the addition of heavy water or the increase of salt concentration, of reducing water activity have a stabilizing effect) are frozen to the liquid crystal. Thus the control at the level of bio-polymers could reduce to the control of whether cellular water is in sol or gel phase and to the understanding of what sol-gel difference means in the many-sheeted space-time.

Local gel-sol transitions could also provide a fundamental mechanism of cellular locomotion applied by, say, amoebae. Quite generally, various conformational changes needed in the cellular control are made possible by a local melting of the gel to sol followed by the conformational change in turn followed by a local sol-gel transition stabilizing the resulting conformation. The technological counterpart of this process is welding. The ME-controlled local melting and solidification of metals might in future technology make possible machines changing their structure routinely.

Local sol-gel transitions could also make possible the control of the conformations of the tubulin dimers expected to be sensitive to the di-electric constant of the water between the alpha and beta tubulin. This would mean that sol-gel phase transition and its reversal could define the bit of the declarative long term memory. Em MEs inducing gel-sol phase transition could provide a precisely targeted control of this kind. This would mean that coherent BE condensed photons associated with MEs could induce the sol-gel phase transition.

What distinguishes between sol and gel phases?

Sol-gel transition is crucial for the polymerization of actin molecules and micro-tubuli, and this dynamics probably involves something more refined than the molecular $k = 137$ metabolism. The dropping of protons/hydrogen atoms or of protonic Cooper pairs from $k = 139$ space-time sheet to larger space-time sheets is thus a unique candidate for what is involved with sol-gel transition.

The liberated zero point kinetic energy would be.1 eV for the dropping of proton or hydrogen atom (if.4 eV is the fundamental metabolic quantum whose value varies roughly in the range.4-.5 eV). For protonic Cooper pairs the energy would be.05 eV. According to the findings of Albrecht-Buehler [I46], the response of cells to IR radiation at.1 eV photon energy is maximal.

The presence of protonic Bose-Einstein condensate at $k = 139$ space-time sheet might thus distinguish between the liquid-crystalline gel phase from sol phase. The particles of this effectively 2-dimensional liquid would be loosely bound tubular structures having a radius of about $L(139)$ and the BE condensate of the dropped proton would bind the water molecules to form this structure. Ordinary water would result when protons at $k = 139$ space-time sheet drop to larger space-time sheets. $k = 139$ space-time sheets would be also associated with small sized water clusters.

This phase could be interpreted in terms of the partially dark water whose existence is suggested by the empirical finding that the chemical formula of water seems to be $H_{1.5}O$ in atto-second scale in the sense that neutron diffraction and electron scattering see only 1.5 protons per oxygen molecule [D16, D15, D18, D8]. As proposed in [K39], every fourth proton would be in dark phase, the lowest dark matter phase and protons would form string like structure which could be regarded as scaled up nuclei consisting of protons (also ordinary nuclei correspond to nuclear strings in TGD framework and exotic $k = 127$ quarks play a key role in the model [K95]).

Attosecond suggests itself as the scale for the average time T_d spent by proton in dark phase in this case. In ordered water the lifetime of this phase might be considerably longer. If a dark

variant of $k = 139$ space-time sheet is in question, T_d is scaled up by $r = \hbar/\hbar_0$. Zero point kinetic energy and the energy of photons would remain invariant, which makes possible quantum coherent control in multi-neuron length scale.

IR radiation as a stabilizer of gel phase?

The model for the effective electronic super-conductivity generalizes to the case protonic Cooper pairs and ionic Bose Einstein condensates, and allows to develop a more precise picture. At the room temperature the thermal photons have energy lower than the zero point kinetic energy .1 eV so that the BE condensate can be maintained only by feeding IR photons kicking the hydrogen atoms back to $k = 139$ space-time sheet with a high enough rate. Therefore the stabilization of the gel phase requires an expenditure of metabolic energy. The simplest view is that in the ground state the entire interior of the cell is in gel phase so that the cell interior would have tonus analogous to muscular tonus.

By stopping the feed of the energy by IR photons to a particular region of cell, gel-sol transition with its various outcomes would occur spontaneously. A faster and energetically more economic manner to achieve the same outcome is to generate negative energy IR photons which induce the dropping of the hydrogen atoms from $k = 139$ space-time sheets. This mechanism also guarantees the stability of polymers by making hydration impossible. A more clumsy manner to guarantee this is to feed protons back to $k = 137$ space-time sheet where they induce dehydration: this process would probably cost much more energy.

Note that the gel-sol transition of the peripheral cytoskeleton assumed to occur during nerve pulse would rely on different different mechanism. Ca^{+2} ions act as cross links between actin molecules and the lengthening of the cytoskeleton-membrane flux tubes in $\hbar$ increasing phase transition makes possible the flow of dark monovalent ions from cell exterior to peripheral cytoskeleton and induces gel-sol phase transition. This phase transition is initiated with the voltage over membrane is reduced to very small value inducing quantum criticality. The proposal is that dark ionic currents from microtubules to axonal membrane induces this reduction.

One can of course ask whether the mere influx of monovalent ions is enough to induce the gel-sol phase transition in the required millisecond time scale. The reduction of cell potential to about.05 V, quite near to the value inducing action potential, implies that the photons of Josephson radiation have energy.05 eV. At this energy a resonant absorption of phase conjugate IR photons by the peripheral cytoskeleton inducing in turn the dropping protons to larger space-time sheet could induce the gel-sol transition.

Cell membrane Josephson junction as a generator IR coherent light

What is then the mechanism generating IR MEs acting as space-time correlates for coherent IR photons? The crucial observation is that the Josephson energy $E_J = ZeV$ for $Z = 2$ for cell membrane Josephson junction is.1 eV at threshold $V = 50$ mV for nerve pulse generation. The value of the metabolic energy quantum varies in certain range and the value .13 eV for the resting potential 65 mV would correspond to.052 eV metabolic quantum. Hence Josephson radiation could take care of kicking protons back to $k = 139$ space-time sheet thus stabilizing gel phase above the threshold for nerve pulse generation. The IR photons generated by Josephson current tend to propagate parallel to the axon and axon could act as a waveguide. When nerve pulse is generated at axonal hillock the frequencies of Josephson radiation are reduced below the threshold allowing stability of gel phase in region near axonal hillock and gel-sol transition should occur.

During nerve pulse the Josephson frequency varies in a wide range and has also negative values during the period when membrane voltage is positive (below 35 meV). A possible interpretation is that a phase conjugate IR radiation with energies $|E| < .07$ eV is generated. These photons could draw protons to large space-time sheet but with kinetic energy $E_0 - E$ rather than at rest.

The scaled up variants of IR photons at higher levels of dark matter hierarchy de-cohering into ordinary IR photons could make possible coherent quantum control in length scales given by $\lambda^n \times \lambda_{IR}$. For instance, EEG photons with frequency of about 5 Hz would correspond to the large $\hbar$ variants of IR photons with the same energy.

What happens in gel-sol phase transition?

The minimal model for the gel-sol transition could be following. When the membrane potential falls below the threshold value, Josephson radiation does not take anymore care of the stability of gel phase in the zone in the radiation zone directed parallel to the axon and gel-sol phase transition is generated in cellular water. The gel-sol transition occurs also at the level of micro-tubules and de-stabilizes them unless they take care of themselves by generating negative energy IR radiation received by cellular water. This might quite well occur.

How Ca^{+2} ions are involved with gel-sol phase transition?

Besides IR MEs also Ca^{+2} ions are involved with the gel-sol transition and if these ions act as cross links between proteins in gel, their role can be understood. Ca^{+2} waves are indeed known to be a fundamental cellular control mechanism. Ca^{+2} ions are known to induce a de-polymerization of micro-tubules even in micro-molar concentrations whereas Mg^{+2} ions having much smaller ionic radius are known to favor the polymerization of the actin molecules [**?**]. Ca^{+2} ions which are more abundant in the cell exterior have a large ionic radius of order .099 nm whereas Mg^{+2} ions, which are abundant in the cell interior, have much smaller ionic radius. This supports the view that these ions have dual roles in cellular control.

As positive ions both Ca^{+2} and Mg^{+2} ions tend to increase the probability of the dropping of protons from the atomic $k = 139$ space-time sheets by repelling the protons from $k = 139$ space-time sheets to larger space-time sheets. This could mean gel-sol phase transition and the transformation of ordered water to ordinary water and the increase in the rate of de-polymerization by hydration. On the other hand, both Ca^{+2} and Mg^{+2} tend to bind with themselves water molecules which lowers de-polymerization rate. For Mg^{+2} with a small ionic radius the latter tendency wins: one can also say that Mg^{+2} is too small to act as a seed for de-polymerization.

Bose-Einstein condensates of bosonic ions are key element of the proposed quantum control mechanism involving charge entanglement induced by W MEs connecting magnetic body and cell interior or exterior. The question is whether de-polymerization involves the charge entanglement of Ca^{+2} and Mg^{+2} ions. One could argue whether the low amount of Ca^{+2} (Mg^{+2}) in cell interior (exterior) actually means that most of Ca^{+2} (Mg^{+2}) ions are in dark phase in cell interior (exterior). If so then at least sol-gel phase transition would be initiated by Josephson radiation and only at the later stages as Ca^{+2} rush into neuronal interior Ca^{+2} take the lead.

11.6.3 Nerve Pulses And Microtubules

As an application of above general view one can consider a model for what might happen during the nerve pulse inside axon and neuronal soma (this time interval can be as long as.5 seconds). The known pieces of information [**?**] indeed fit nicely with the above general principles and one ends up with the following scenario. Note again that this scenario has not been updated to correspond to the most recent view about nerve pulse.

Propagating sol-gel transitions as representations of declarative memories

The propagation of nerve pulse along axon means a propagation of gel-sol-gel phase transition along microtubule. Declarative long term memories could correspond to the temporal sequences of nerve pulses represented as propagating gel-sol-gel phase transitions. The representation of memories would be rather rough as compared to the capacity of microtubular conformations to represent bits: for a conduction velocity $v = 10$ m/s and duration of pulse about 1 ms single pulse would correspond to an axonal length of 10^{-5} meters meaning that 10^3 conformational bits would lumped to single bit

What happens inside neuron soma as nerve pulse is generated?

Consider first what could happen inside neuronal soma as nerve pulse is generated.

1. The positive energy Josephson radiation at IR frequency generated by cell membrane Josephson junction ceases temporarily and induces gel-sol transition in cellular water. Ca^{+2} ions

flowing into the neuronal interior favor further the de-polymerization of actin molecules. The micro-tubules of cytoskeleton receive the stabilizing IR radiation still from parts of neuronal membrane other than the throat of axon. They can also take care of themselves by sending phase conjugate IR radiation received by cellular ordered water.

2. The hydration of actin molecules in the vicinity of axonal hillock means that the activity of the water is reduced inside cell and water molecules from the cell exterior rush to the cell interior. The resulting swelling of the cell tears the positively charged ends of the micro-tubuli from the cell membrane. The micro-tubuli are now free to change their conformations and the micro-tubuli associated with different cells can arrange themselves in parallel configurations temporarily. Therefore they could act as quantum antennas generating coherent IR light needed to re-establish the gel phase very effectively: in an ideal case the power radiated is proportional to N^2, N the number of synchronously firing neurons. Also the return of membrane potential to the resting value brings back the IR radiation stabilizing the gel phase.

3. Gel phase is re-generated. Actin molecules re-polymerize and micro-tubuli stick again to the cell membrane. Synaptic contacts and the distribution of the ionic channels in neuronal membrane are re-structured in the process and this means that learning occurs in the sense that cell begins to respond slightly differently to neuronal inputs. This does not correspond to conscious long term memories, which are represented as temporal conformational patterns of tubulin dimers. These memories are in the geometric past, and can change, and are re-experienced by sharing of mental images or communicating the memories classically as field patterns associated with MEs using memetic code.

4. Tubulin dimers are electrets and can be regarded as miniature capacitor plates containing 18 Ca^{+2} ions at the other plate and 18 electrons at the other plate [**?**, **?**]. The average increments of WCW zero modes in the quantum jump sequence giving rise to the change of the conformation defines a two-valued geometric quale characterizing single bit of the long term memory. In [K67] a micro-tubular spatial cognitive code based on 13×13 bits is discussed. Temporal pattern extends this code to $13 \times 13 \times 126$ bit code.

Could micro-tubule-axon system perform topological quantum computation?

The proposed picture is consistent with the model of DNA as a topological quantum computer [K2] and with the idea that also micro-tubules could be involved with TQC. The model of DNA as TQC in its basic form assumes that DNA is connected to the nuclear membrane and cell membranes associated with the cell body by magnetic flux tubes such that each nucleotide is connected to single lipid. Tqc programs are coded to the temporal braiding patterns of lipids. This requires that lipid layer is liquid crystal and thus below the critical temperature. The flux tube connecting DNA to inner lipid layer and that beginning from outer lipid layer can form single flux tube or be split. If they form single flux tube braiding and TQC are not possible. During TQC the braid strands going through cell membrane are split and the dance of lipids induced by water flow defining time like braiding (hydrophilic lipid ends are anchored to the cellular water) induces braiding of the magnetic flux tubes which write the TQC program to memory. Furthermore, the lifetimes of flux tubes in the connected state must be short enough to prevent the generation of a nerve pulse. This is the case if the temperature is sufficiently below the critical temperature. The ionic supra currents are identifiable as the observed quantal non-dissipative currents flowing through the cell membrane when TQC is not on.

Centrioles have their own genetic code realized in terms of RNA and they play key role during gene replication when DNA is out of the game. This encourages to think that micro-tubules make possible an independent TQC like process. The question is how micro-tubule-axon system could perform TQC assuming that the recent picture about DNA as TQC [K2] is roughly correct. The assumptions of the model relevant for the recent situation are following.

1. Flux tubes consists of pieces between standard plugs represented by hydrogen bond acceptors ($O =$, aromatic rings, ...). For instance, XYP molecules, $X = A, T, C, G$, $Y = M, D, T$ would represent standard plugs and that the transformation $XTP \to XDP + P_i$ represents

the splitting of the flux tube and thus of braid strand. The XMPs associated with DNA would represent the ends of the braid strands. The formation of hydrogen bond between water molecule and $O =$ associated with phosphates at the hydrophilic ends of phospholipids would initiate TQC [K2].

2. In the model for protein folding [K6] free amino-acid corresponds to a codon XYZ in the sense of wobble base pairing meaning that the third nucleotide corresponds to a quantum superposition of colors of nucleotides coding for the same amino-acid. Hydrogen bonds correspond flux tubes also and hydrogen bonds between $N - H$ and $O =$ groups in alpha helices and beta sheets mean a shortcut making it impossible to continue the flux tube from $O =$ further. Only the continuation of the flux tube through non-hydrogen bonded $O =$ acting as a plug is possible. $Y = Z$ rule holds true for the $O = -N - H$ hydrogen bonds and defines folding code. Inside proteins amino-acids correspond to code YZ part of the codon XYZ and inside alpha helices and beta sheets the flux tubes from DNA would end to amino-acids and for them one could have only braiding between DNA and tubulins. Only in the case of non-hydrogen bonded amino-acids the flux tube connection from DNA could continue to the lipid layer and only in this case one could have the generalization of DNA TQC with flux tubes connecting DNA via tubulins to the axonal lipid layer.

Taking this picture as a starting point one can consider several options. For two first options tubulins are basic units. For the third one DNA nucleotides and amino-acids would have this role.

Option I: Tubulins could be connected to the lipid layer of the axonal membrane by flux tubes and the melting of the axonal membrane would induce braiding during the propagation of nerve pulse. α tubulins are accompanied by stable GTPs analogous to single DNA nucleotide so that α tubulin could takes the role of DNA nucleotide with braid strands to lipids having only single color. Compared to DNA TQC this computation would represent much rougher resolution. β tubulins are accompanied by unstable GTPs able to suffer a hydrolysis to GDP. Also this process would correspond to the splitting of flux tube but the connection to TQC remains unclear. One can imagine one/two connected flux tubes to lipid layer represents bit.

Option II: For some years ago I considered the possibility of a gel-sol-gel phase transition proceeding along the surface surface of the micro-tubuli, accompanying nerve pulse, perhaps inducing nerve pulse, and coding for long term sensory memories in terms of 13 13-bit sequences defined by the tubulin helices with bit represented as a conformation of micro-tubule. This hypothesis might be easily shown to be wrong on basis of the available experimental facts already now. Suppose however that this phase transition happens and that the braid strands do not continue from the micro-tubular surface to the cell nucleus. In this case the braiding could be induced by a gel-sol-gel transition accompanying and perhaps generating the nerve pulse at the micro-tubular level and inducing the disassembly of the microtubule to tubulins followed by re-assembly inducing the braiding. Also this braiding would contribute to TQC like process or at least to a memory storage by braiding and options I and II would provide the complete story.

Option III: What about the variant of DNA-membrane TQC for axons? In the model of DNA as TQC these flux tubes continue back to the nucleus or another nucleus: the flux tubes must be split at cell membrane during TQC and this splitting induces the required isolation from the external world during TQC. During nerve pulse the situation would be different and the flow of lipids in liquid phase could induce DNA-lipid layer braiding: the isolation could however fail now. Tqc would explain why the axon melts during nerve pulse.

There are objections against this option.

1. By previous argument only Y-codons of DNA and only non-hydrogen bonded $O =$s of amino-acids would contribute to the braid strands. This does not look nice.

2. The idea about magnetic flux tubes emanating from DNA and flowing along micro-tubules interiors and radiating to the axonal membrane looks also ugly: in any case, this would not affect TQC and nerve pulse could be seen as a direct gene expression not conforming with the idea that microtubules define an independent computational system.

3. One can wonder why also the magnetic flux tubes from DNA could not end to the space-time sheet of the cell exterior if they do so in the case of axon. The justification for "No" (besides

isolation) could be that also cell soma would possess standing soliton sequence like waves and standing nerve pulses in this kind of situation.

The following considerations do not depend on the option used.

1. What comes first in mind is that the braiding codes memories, with memories understood in TGD sense using the notion of 4-D brain: that is in terms of communications between brain geometrically now and brain in the geometric past. In standard neuroscience framework braiding of course cannot code for memories since it changes continually. Nerve pulse sequences would code for long term sensory memories in a time scale longer than millisecond and micro-tubular phase transition could have a fine structure coding for sensory data in time scales shorter than nerve pulse duration. The fact is that we are able to distinguish from each other stimuli whose temporal distance is much shorter than millisecond and this kind of coding could make this possible. Also the direct communication of the auditory (sensory) input using photons propagating along MEs parallel to axon could also explain this.

2. In the model of DNA as TQC nucleotides A, T, C, G are coded into a 4-color of braid strand represented in terms of quarks u, d and their antiquarks. An analogous coding need not be present also now: rather, all braid strands could have same color represented by G of GTP. Tubulins could be seen as higher level modules consisting of order hundred 500 amino-acids. This corresponds to a DNA strand with length of about.5 μm corresponding to the p-adic length scale $L(163)$ which is one of the four magic p-adic length scales ($k = 151, 157, 163, 167$) which correspond to Gaussian Mersennes. This higher level language character of micro-tubular TQC programs would conform with the fact that only eukaryotes possess them.

3. Cellular cytoskeleton consists of micro-tubules. Could micro-tubular TQC -in either of the proposed forms- take place also at the cell soma level? Could DNA-nuclear membrane system define the primordial TQC and micro-tubular cytoskeleton-cell membrane system a higher level TQC that emerged together with the advent of the multicellulars? Is only the latter TQC performed at the multicellular level? The notions of super- and hypergenome encourage to think that both TQCs are performed in all length scales. One can imagine that ordinary cell membrane decomposes into regions above and below the critical point (the value of the critical temperature can be controlled. Those below it would be connected to DNA by flux tube bundles flowing inside the micro-tubular cylinders. Micro-tubular surfaces would in turn be connected to the regions above the critical point. One should also understand the role of $M_{13} = 2^{13} - 1$ 12-bit higher level "genetic code" assignable naturally to micro-tubules. For instance, could the bit of this code tell whether the module defined by the tubulin dimer strand bundle participates TQC or not?

11.6.4 Magnetic Bodies, MEs And Microtubules

It would seem that magnetic bodies are the intentional agents and the most natural assumption is that micro-tubuli are used by the magnetic body of cell for logistic purposes as well as to represent memories. First p-adic MEs representing the intention to suck energy and momentum from a particular part of the gel phase and transformed then to negative energy IR MEs by p-adic-to-real transition. Negative energy IR MEs would also serve as space-time correlates for the bound state quantum entanglement responsible for the generation of a multi-neuron macroscopic and -temporal quantum state.

Phase conjugate laser beams are the most plausible standard physics analogs for negative energy MEs and the coherent photons generated and Bose-Einstein condensates of photons contained by them. Since the energy.1 eV is above the range of the thermal energies, one can argue that negative energy photons can be absorbed only resonantly and thus very selectively. This view is supported by the demonstration of Feinberg showing that it is possible to see through chicken using phase conjugate laser beam [D2].

Still an open question is whether laser beams actually correspond to dark photons having thus large value of $\hbar$ and scaled up wavelength. Scaled up wave lengths for.1 eV IR photons would be very natural concerning the control in length scales longer than that of single neuron and synchronous neuronal firing might involve the de-coherence of these dark photons to ordinary IR photons.

Could memes express themselves in terms of modulated IR radiation?

In TGD framework cell nucleus is the brain of the cell and acts as the fundamental controller of the cellular dynamics. Genetic expression is the slow part of this dynamics analogous to a rebuilding of the computer hardware. Software corresponds to memes, sequences of memetic codons realized as sequences of 21 DNA triplets in the intronic part of the DNA. Memetic codons would be the language with which the cellular programs are written. Super-genes or at least hyper-genes would naturally correspond to the sequences of memetic codons.

Memes could express themselves as temporal patterns of IR radiation amplified by micro-tubuli of length ~ 12.4 micrometers. Of course, in accordance with the fractality, also wavelengths corresponding to other metabolic currencies are probably realized. Single memetic codon carries 126 bits and single bit has a duration of about 1/1026 s, the basic time scale of the neuronal dynamics. Both the frequency for the occurrence of sol gel transition and the duration of memetic codon in turn corresponds to 10 Hz frequency in alpha band, which suggests that $k_d = 46$ hierarchy level of dark matter hierarchy is involved with the periodically occurring sol-gel phase transition. The general framework would suggest that this phase transition occurs with this frequency only in vertebrate neurons.

These patterns of IR radiation at $\sim .1$ eV energy induce temporal sequences of sol-gel transitions representing memes physically. The beauty of MEs is that as topological field quanta of radiation they allow a precisely targeted local control not possible in Maxwellian electrodynamics. In particular, temporal sequences of micro-tubulin conformations could represent long term declarative memories expressed in a universal language using memetic codons as basic units.

Seesaw mechanism as a general manner to generate long term memories?

Micro-tubuli can act as quantum antennae producing IR photons by the dropping of proton Cooper pairs and amplified resonantly, when the micro-tubule has a length of about 12.4 micrometers. The absorption of these photons would in turn re-establish the gel phase in receiving system. This energetic gel-sol seesaw would be obviously ideal for the minimization of the dissipative losses.

The seesaw mechanism for the cellular control by micro-tubuli means that sol-gel transition in tubulin induces a gel-sol transition in the controlled part of the cell. Thus it would automatically construct micro-tubular declarative long term memory representation as a record about sol-gel transition history in various parts of the cell or cell substructure coded by the positions of tubulin dimers at the tubulin cylinder.

These dynamical maps about the active structures in the cell interior would be analogous to neuronal maps in cortex. If cell nucleus is the fundamental controller, also chromosomes might be seen as structures analogous to brain hemispheres forming dynamical sensory and motor maps about the interior of the cell. The static conformations would not represent memory bit. Rather, the changes of the conformations would represent the bit in accordance with the view that moments of consciousness correspond to quantum jumps between histories, and that the sequence of quantum jumps effectively integrates to a single quantum jump during macro-temporal quantum coherence.

11.7 Are lithium, phosphate, and Posner molecule fundamental for quantum biology?

I encountered a very interesting Facebook link (see `http://tinyurl.com/zyy3b4l`) to the work of Mathew Fisher [?] (see `http://tinyurl.com/hd3t6sr`) related to quantum biology, in particular to the possible role of Posner molecules. Posner molecules (see `http://tinyurl.com/ya2vura9`) are not some bio-chemical rarity. Betts and Posner, while examining the x-ray crystal structure of the bone mineral hydroxyapatite $Ca_{10}(PO_4)_6$ (see `http://tinyurl.com/y7quv997`), found that within each unit cell there were two calcium-phosphate clusters with atomic constituents $Ca_9(PO_4)^6$.

I attach below the abstract of the first article [?] of Fisher.

> *The possibility that quantum processing with nuclear spins might be operative in the brain is proposed and then explored. Phosphorus is identified as the unique biological element with a nuclear spin that can serve as a qubit for such putative quantum processing - a neural qubit - while the phosphate ion is the only possible qubit-transporter.*

We identify the ■, $Ca_9(PO_4)^6$, as the unique molecule that can protect the neural qubits on very long times and thereby serve as a (working) quantum-memory.

A central requirement for quantum-processing is quantum entanglement. It is argued that the enzyme catalyzed chemical reaction which breaks a pyrophosphate ion into two phosphate ions can quantum entangle pairs of qubits. Posner molecules, formed by binding such phosphate pairs with extracellular calcium ions, will inherit the nuclear spin entanglement. A mechanism for transporting Posner molecules into presynaptic neurons during a ■ exocytosis, which releases neurotransmitters into the synaptic cleft, is proposed. Quantum measurements can occur when a pair of Posner molecules chemically bind and subsequently melt, releasing a shower of intra-cellular calcium ions that can trigger further neurotransmitter release and enhance the probability of post-synaptic neuron firing. Multiple entangled Posner molecules, triggering non-local quantum correlations of neuron firing rates, would provide the key mechanism for neural quantum processing. Implications, both in vitro and in vivo, are briefly mentioned.

The model of Fisher [**?**] (see `http://tinyurl.com/hd3t6sr`) for how phosphate ion and calcium phosphate known as Posner molecule could play a central role quantum neural processing is described. Fisher assumes that the nuclear spin $S = 1/2$ of phosphate ions could make possible long range correlations and allow long decoherence lifetimes in these degrees of freedom. Fisher emphasizes also the possible role of Lithium in quantum biochemistry.

About two years after writing the first version of this article, I learned about a second article about Posner molecules by Fisher, Swift and Van de Walle [**?**] (see `http://tinyurl.com/ycyu5bj9`) describing a detailed study of Posner molecules. The abstract of the article gives idea about what is done.

We investigate ■, calcium phosphate clusters with chemical formula $Ca_9(PO_4)^6$. Originally identified in hydroxyapatite, Posner molecules have also been observed as free-floating molecules in vitro. The formation and aggregation of Posner molecules have important implications for bone growth, and may also play a role in other biological processes such as the modulation of calcium and phosphate ion concentrations within the mitochondrial matrix. In this work, we use a first-principles computational methodology to study the structure of Posner molecules, their vibrational spectra, their interactions with other cations, and the process of pairwise bonding. Additionally, we show that the Posner molecule provides an ideal environment for the six constituent ^{31}P nuclear spins to obtain very long spin coherence times. In vitro, the spins could provide a platform for liquid-state nuclear magnetic resonance quantum computation. In vivo, the spins may have medical imaging applications. The spins have also been suggested as ■ in a proposed mechanism for quantum processing in the brain.

I also learned about the finding of M.Y. Simmons *et al* [D10] (see `http://tinyurl.com/ydx6v7xa`) about electronic qubits realized with phosphorus atoms serving as donors. This inspires the question whether also electronic qubits might be realized by using the valence electrons of P.

About two years after writing the first version of this article I ended up with a model of valence bond [L34] (see `http://tinyurl.com/ycg94xpl`) assuming that the electrons at valence bonds can have non-standard value of Planck constant $h_{eff} = n \times h$ (the hierarchy of Planck constants characterizing dark matter as phases of ordinary matter comes as a basic prediction of adelic TGD [L39, L38]). The starting point of the model was the surprisingly weak variation of the bond energy along the rows of the periodic table.

The model provides a vision about the role of valence bonds in biology and provides a precise identification for the notion of metabolic energy. The binding energies of bonds decrease with the value of $h_{eff}/h = n$ increasing along the rows of the periodic table, and the reduction of the binding energy can be identified as potential metabolic energy liberated in catabolism. The bonds involving atoms towards the right end of the rows of the periodic table have highest metabolic energies, and are indeed the bonds appearing in nutrient molecules. Phosphate ion has especially high bond energy so that Posner molecules could be also ideal for storing metabolic energy.

In the sequel I will consider the proposal of Fisher from TGD view point. I will describe first the Lithium mystery, which served as a motivation of Fisher and also TGD view about the

role of Lithium. I also present TGD view about the situation suggesting that Posner molecule might indeed have a deep role but perhaps also in different sense to that in Posner's proposal. ELF radiation at frequencies equal to multiples of 15 Hz cyclotron frequency for Calcium ion in endogenous magnetic field $B_{end} = .2$ Gauss was found by Blackman and others to have effects on vertebrate brain. Furthermore, the cyclotron frequency of phosphate ion in endogenous magnetic field B_{end} corresponds to the 10 Hz alpha resonance frequency defining a fundamental biorhythm. This suggests that Ca ions and phosphate ions might form two separate cyclotron Bose-Einstein condensates at different magnetic flux tubes so that cyclotron energies. I will also represent a brief comment about the realization of electronic qubits with P atom serving as a donor.

11.7.1 Lithium mystery

The starting point of Fisher was a very interesting finding challenging the hypothesis about life as mere bio-chemistry. Already in 1986, scientists at Cornell University examined the effects of the two isotopes of Lithium on the behavior of rats. Pregnant rats were separated into three groups. One group was given Li^7, one group was given the isotope Li^6, and the third served as the control group. Once the pups were born, the mother rats that received Li^6 showed much stronger maternal behaviors, such as grooming, nursing and nest-building, than the rats in either the Li^7 or control groups.

Li^6 therefore as has a positive effect on maternal behaviour unlike Li^7. The chemistry is exactly the same. According to the popular article, Fisher believes that the higher nuclear spin of Li^6 could give it special role.: in the article he talks about nuclear spin $J = 1/2$ which cannot be true since the spin must be even. As a matter fact, according to my Nuclear Physics by Howard Li^7 has nuclear spin of $J = 3/2$ units whereas Li^6 has nuclear spin $J = 1$ so that neither of the above claims is correct. Could the bosonic character of Li^6 nucleus provide an alternative explanation? In any case, the finding strongly suggests that magnetic fields are involved.

Lithium - presumably Li^6 - has also other positive effects. If the positive effects are indeed due to Li^6 isotope, the dose of Lithium could be reduced by using only Li^6 isotope. I attach here the abstract of the article that I wrote as a reaction to discussions with my friend Samppa who told about Lithium [L28] (see `http://tinyurl.com/j44epwp`).

> 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 effectiveness of Lithium is however difficult to understand in the standard framework of biology. In TGD framework organism-environment pair of standard biology is replaced with the triplet magnetic body - organism -environment. 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. Magnetic body does not receive information about brain and cannot control it since dark Lithium ions and correspond- ing cyclotron radiation are not present. The disorders caused by the lack Lithium and other biologically important ions would therefore be something totally new from the perspective of standard neuroscience.

TGD explanation for the effects of Lithium relies on the notions of magnetic body and dark large $h_{eff} = n \times h$ photons, electrons, and ions and relies on cyclotron frequencies as frequencies assignable to the dark photons responsible for the communications between magnetic body and biological body. In this picture the charge of the ion and its total magnetic moment would be relevant rather than only nuclear magnetic moment characterizing also neutral atoms (which could also contribute to the magnetic moment of ion). Cyclotron frequencies would replace Larmor frequencies.

1. For Li^6 the cyclotron frequency is about 50.0 Hz in the endogenous magnetic field $B_{end} = .2$ Gauss explaining the quantal effects of em fields at ELF frequencies on vertebrate brain reported by the pioneers of bio-electromagnetism such as Blackman [**?**] to occur at multiples of cyclotron frequency in this magnetic field for Calcium ion and also for other biologically important ions. For Ca^{+2} ion the cyclotron frequency is 15 Hz. Thanks to the large value

of $h_{eff} = n \times h$ dark photons would have energies above thermal threshold. An attractive hypothesis is that the energies are in the range of bio-photon energies (visible and UV).

2. In the case of Li^6 the dark photons would make possible communication to and control by the magnetic body relevant for maternal behaviors. Magnetic fields oscillating at 50 Hz frequency are known to have biological effects [K76]. 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 $2B_E/5$.

3. For Li^7 the dark photons would have cyclotron frequency about 42.9 Hz, which brings in mind the thalamocortical resonance with frequency around 40 Hz assigned to consciousness at the time when the use of the word "consciousness" ceased to be pseudo-science. The more abundant Li^7 (92.5 per cent) should be also important but could be associated with other kinds of biological functions.

11.7.2 Phosphate, Posner molecule, and cognition

Fisher as also other quantum biologists tries to understand quantum biology as an improvement of biochemistry. One assumes that standard quantum theory brings in small effects allowing to optimize biological functions. In the case of the avian navigation and also in many other situations the problem is that Earth's magnetic field is only 2 per cent of the minimum magnetic field at which the proposed radical-pair mechanism is found to work [L23] (see `http://tinyurl.com/jnxvdmf`). To my opinion much more radical approach challenging the basics of quantum theory itself is necessary.

Fisher wants to identify the quantum mechanism behind neural activity assumed to rely on nuclear spins. This is quite a demanding challenge. One should understand long coherence time for nuclear spins representing the qubits, discover a mechanism transporting the qubit through the brain to neurons, identify a molecular scale quantum mechanism entangling qubits, identify a chemical reaction inducing quantum measurement of the qubits dictating the subsequent neuron firing, and understand what happens in nerve pulse transmission from pre- to post-synaptic neuron at quantum level.

1. Fisher assigns fundamental qubit and the ability to develop lon lasting quantum entanglement with phosphate ion (see `http://tinyurl.com/zgbgtwy`). Phosphate ion would be qubit transporter. The transfer of phosphate ion from APT to a molecule is fundamental part of metabolism and the TGD proposal is that a transfer of negentropic entanglement (NE) (purely TGD based notion involving p-adic physics as correlate for cognition) is in question.

2. Enzyme catalyzed qubit entanglement would emerge in the reaction ATP$\rightarrow$ AMP+PPi. PPi is diphosphate ion with entangled phosptate and the reaction PPi$\rightarrow$ Pi+Pi would create two entanglement phosphates. The reaction rate is proposed to depend on whether the 2Pi state is spin single or spin triplet.

3. Quantum memory is assigned with so called Posner molecule $[(PO_4)^{-3})]_6Ca_9^{+2}$ made of 6 phosphate ions and 9 calcium ions would be the key player. Posner molecule belongs to a family of calcium phosphates having as building bricks PO_4^{-3} and Ca^{+2} ions (see `http://tinyurl.com/jftjmro`). Calcium phosphate is the principal form of calcium found in bovine milk and blood. 70 percent of bone consists of hydroxyapatite, a calcium phosphate mineral known as bone mineral. Tooth enamel is composed of almost ninety percent hydroxyapatite.

   Posner molecule is neutral since the charges of 9 Ca ions and 6 phosphate ions cancel each other: $9 \times 2 - 6 \times 3 = 0$. Geometrically Posner molecule can be described as a cube with Calcium ions at corners and center and phosphate ions at the centers of faces. The nuclear spin of the Posner molecule assignable to phosphates is 0, 1, 2, or 3. Posner molecule has also reduced rotational degrees of freedom characterized by group Z_3 giving rise to pseudospin. Posner molecule would be a carrier of phosphate qubits giving rise to (working) quantum-memory realized in terms of entangled Posner molecules.

4. Fisher proposes the notion of quantum entangled chemical reactions. This notion does not make sense if one identifies chemical reactions as processes involving state function reduction as assumed in chemical kinetics. The notion could make sense if chemical reactions are identified as unitary time evolutions for entangled systems such as Posner molecules. In TGD framework the notion of entangled time evolutions could make sense in zero energy ontology (ZEO).

5. Nerve pulse tranmission from pre- to postsynaptic membrane would entangle neurons by entangling Posner molecules. Biochemistry is complex but to my opinion the proposed model is too complex to be feasible. My view is that the enormous complexity of the description based on biochemical reaction pathways reflects the failure to realize the presence of control level - magnetic body. Situation would be like trying to understand the functioning of computer program regarding it as mere physical phenomenon without any idea about its purpose.

11.7.3 TGD view

In TGD framework both nuclear spins and angular moment of dark nuclei in the magnetic fields assignable to dark magnetic flux tubes would be important: Larmor frequencies would be replaced with the sums of Larmor - and cyclotron frequencies assignable to (usually) charged particles. It is interesting to look whether the cyclotron frequencies of phosphate and Posner molecule could teach something about their possible role.

1. Phosphate PO_4^{-3} with mass number $31 + 4 \times 16 = 95$ has cyclotron frequency 9.5 Hz in the endogenous magnetic field $B_{end} = .2$ Gauss assumed in TGD model and therefore in alpha band. For smaller charges -2 and -1 one has frequencies 6.26 Hz and 3.13 Hz. In TGD framework the transfer of phosphate from ATP to the acceptor bio-molecule could be at the fundamental level transfer of NE from metabolites [K53, K54]. This could reduce to the transfer the ends of the associated flux tubes between the molecules.

2. Posner molecule is neutral since the charges of 9 Ca ions and 6 phosphate ions cancel each other: $9 \times 2 - 6 \times 3 = 0$. Being neutral Posner molecule as a whole does not couple to the magnetic field except through its total magnetic moment. TGD proposal that ions form Bose-Einstein condensates encourages however to consider the possibility that the building bricks of Posner molecule form separate Bose-Einstein condensates. One can ask whether this is possible also more complex calcium phosphates: could bones be much more than just passive building bricks?

   The simplest possibility is that 3 Cooper pairs of fermionic PO_4^{-3} molecules (as is easy to check by noticing that phosphorus and oxygen atoms are bosons and there are surplus 3 electrons: note that phosphorus nucleus is fermion and oxygen nucleus a boson) form a Bose-Einstein condensate a their own circular portion of flux tube. 9 bosonic Ca^{+2} ions would form similar Bose Einstein condensate at their own flux tube portion.

3. The value of h_{eff} proportional to the mass of the ion if $h_{eff} = h_{gr}$ hypothesis is accepted. The formation of Cooper pairs of phosphate ions would conform with the conjecture of Fisher that two phosphate ions can entangle.

   These observations put the bells ringing - with a frequencies of 10 Hz and 15 Hz, one might say. Unfortunately this frequency is not directly audible, so that I cannot hope that colleagues would hear the ringing! There are however some hopes: also 10 Hz and 15 Hz can be made audible as difference of frequencies fed to right and left ear! Maybe some experimentalist could get interested!

4. A further intriguing observation is that the Larmor frequency of P for B_{end} is 10.96 Hz. This is marginally in alpha band. This suggests that also Larmor frequency of P is indeed important in bio-control by magnetic body.

5. An alternative and more realistic sounding hypothesis is $h_{eff} = h_{em}$. $h_{eff} = h_{em}$ 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 [K31, K32, K33, K34]. 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 NE or be accompanied by dark magnetic flux tube.

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.

6. The cyclotron frequencies of these Bose-Einstein condensates would be 9.5 Hz *resp.* 15 Hz in $B_{end} = .2$ Gauss. This model could allow to improve the understanding about why the radiation at harmonics of 15 Hz has effects on vertebrate brain and also about the realization of alpha rhythm as a control signal from magnetic body. Fisher proposes that in nerve pulse transition two Posner molecules fuse temporarily and produce a spray of Ca^{+2} ions. This could make sense also in TGD framework.

11.7.4 A new step of progress after two years

Roughly two years after writing the first version of this article I ended up with a model of valence bond [L34] (see `http://tinyurl.com/ycg94xpl`) assuming that the electrons at valence bonds can have non-standard value of Planck constant $h_{eff} = n \times h$ (the hierarchy of Planck constants characterizing dark matter as phases of ordinary matter comes as a basic prediction of adelic TGD [L39, L38]). The starting point of the model was the surprisingly weak variation of the bond energy along the rows of the periodic table and the observation that the heating of Ruthenium leads to a mysterious disappearance of valence electrons known for decades: the interpretation would be that they are transformed to dark electrons [L37].

The model provides a vision about the role of valence bonds in biology and provides a precise identification for the notion of metabolic energy. The binding energies of bonds decrease with the value of $h_{eff}/h = n$ increasing along the rows of the periodic table, and the reduction of the binding energy can be identified as potential metabolic energy liberated in catabolism. The bonds involving atoms towards the right end of the rows of the periodic table have highest metabolic energies, and are indeed the bonds appearing in nutrient molecules. Phosphate ion has especially high bond energy so that Posner molecules could be also ideal for storing metabolic energy.

Posner molecule would be ideal for both control purposes and for metabolism.

1. There are 9 Ca^{2+} ions and 6 PO_4^{3-} ions with cyclotron frequencies of 15 Hz and 9.5 Hz respectively in the endogenous magnetic field $B_{end} = .2$ Gauss explaining the observations of Blackman [**?**] about the quantal effects of ELF em fields on vertebrate brain: thus these molecules are ideal for control by and communication to magnetic body.

   Also the fact that the Larmor frequency of P is 10.96 Hz and marginally in alpha band, suggests that MB uses spin flips for control purposes. MB could control and coordinate all phosphate containing biomolecules usign this Larmor transition of P. This includes ATP, DNA, RNA, the tubulins of microtubules containing GTP and all biomolecules to which phosphate is attached. This would conform with the frequencies in alpha band as a universal biorhythm used by magnetic body to keep metabolism in synchrony in body scale.

   P nuclei serve as qubits and 6 qubits in Posner atom could realize genetic code with 64 code words. Could our bone marrow be performing massive quantum information processing?!

2. The 6 phosphates with high energy phosphate bonds are in turn ideal for metabolism: P and O related valence bonds indeed have nearly maximal metabolic energy content in the

proposed model of valence bonds based on $h_{eff}/h = n$ hierarchy [L34] (see `http://tinyurl.com/ycg94xpl`).

Remark: Totally unrelated association: the magic number 6 appears also in the structure of cortex: could the six layers represent qubits and realize genetic code?

This suggests that bones might also serve as energy storages and - of course - as nutrients. Interestingly, in the evolution of humans the discovery of stones as tools to break down bones of prey animals to get bone marrow has been seen as a critical step leading to the growth of cortex requiring a lot of metabolic energy (to generate large n valence bonds providing ability to generate negentropy).

What is interesting that ATP molecule - the basic metabolic currency - has triphosphate with total charge -4 as a building brick. Triphosphate is characterized by cyclotron frequency 4.8 Hz which is one half of the alpha band frequency. The diphosphate in ADP has cyclotron frequency 5.2 Hz. Note that the cyclotron frequency of Fe^{2+} ion central in oxygen based metabolism is 10.7 Hz and in alpha band as also the Larmor frequency of P.

Note that in DNA the singly charged phosphates in XMPs, X = A, T, C, G, have cyclotron frequency, which is one third of this, that is 3.1 Hz. This frequency appears in EEG as a kind of resonance frequency during deep sleep. DNA nucleotides as whole have cyclotron frequencies around 1 Hz. In microtubules the phosphate of GTP can have three different charge states allowing frequencies 3.1,6.2 and 9.4 Hz. I have proposed that these charge states together with two different tubulin conformations give rise to a realization of the genetic code.

The proton cyclotron frequency 300 Hz has been already earlier assigned with ATP and the models for the lifelike properties of a system consisting of plastic balls involved cyclotron frequency of Ar^+ ion which is same as that of Ca^{2+} ion and cyclotron frequency 300 Hz of proton [L36] (see `http://tinyurl.com/yassnhzb`). Also the two important frequencies associated with honeybee dance [L46]correspond to the cyclotron frequencies of Ca^{2+} and proton (see `http://tinyurl.com/ycnst4z5`).

11.7.5 Phosphorus electrons as qubits

M.Y. Simmons *et al* [D10] (see `http://tinyurl.com/ydx6v7xa`) have found that P atoms can serve as donors of electrons giving rise to very long-lived qubits (see `http://tinyurl.com/y88d7vhf`). I attach the abstract of the article here.

Substitutional donor atoms in silicon are promising qubits for quantum computation with extremely long relaxation and dephasing times demonstrated. One of the critical challenges of scaling these systems is determining inter-donor distances to achieve controllable wavefunction overlap while at the same time performing high fidelity spin readout on each qubit. Here we achieve such a device by means of scanning tunnelling microscopy lithography. We measure anti-correlated spin states between two donor-based spin qubits in silicon separated by 16±1nm. By utilising an asymmetric system with two phosphorus donors at one qubit site and one on the other (2P1P), we demonstrate that the exchange interaction can be turned on and off via electrical control of two in-plane phosphorus doped detuning gates. We determine the tunnel coupling between the 2P1P system to be 200MHz and provide a roadmap for the observation of two-electron coherent exchange oscillations.

A controllable exchange interaction between electron spins is needed for the realization of 2-qubit quantum gate. The valence electron of P atom rather than P nucleus serves as a qubit. The qubits have unexpectedly long relaxation times (measured in seconds) and dephasing times. $2P$ (2 P atoms) and $1P$ serve as electron donors. The distance of 2P and 1P is rather long - 16 ± 1 nm - 1.6 times the p-adic length scale $L(151)$ (p is Gaussian prime $M_{G,151} = (1+i)^{151} - 1$ assignable to neuronal membrane. Exchange interaction occurs if there is an overlap between electron wave functions.

In TGD framework the electrons donated by phosphorus atoms and forming the qubits could be actually dark electrons with $h_{eff}/h = n$ larger than for atoms or normal valence bonds. This would scale up the domain of electron wave functions by n^2 and make possible the overlap. This also increases relaxation and dephasing times.

Remark: In living matter negatively charged phosphate ions for which P atoms have received electrons (negative oxidation number) are important. In the experiment discussed P atom loses electron and becomes a positive ion.

11.8 DMT, pineal gland, and the new view about sensory perception

The recent discussions with artist Sini Kunnas [L30] about perception as creation of an artwork inspired additional insights about how sensory perception, imagination as almost sensory perception, dreams and hallucinations as virtual percepts, and their motor analogs relate to each other.

What distinguishes TGD from neuroscience is that sensory receptors are assumed to serve as carriers of sensory percepts. Zero energy ontology (ZEO) providing new view about time and memory allows to solve the basic objections related to phantom limb phenomenon: pain in phantom limb would be sensory memory.

The assumption that sensory percepts are artworks rather than passive records of sensory input requires virtual sensory input from brain to sensory organs and build-up of the final percept by pattern recognition - an iterative procedure involving very many forth-and back signals. Nerve pulse transmission is quite too slow process to allow this and signals propagating with maximal signal velocity are suggestive.

Nerve pulses and neurotransmitters would not represent real communication but give rise to temporary intra-brain communication lines along which communications as dark photon signals would take place with maximal signal velocity using dark photons (characterized by $h_{eff}/h = n$) transforming to biophotons in an energy conserving manner [L11, K13]. Neurotransmitters and also other information molecules (hormones, messengers) attached to receptors would serve as bridges fusing permanent but disjoint communication lines along axons to a connected temporary communication line for dark photons to propagate. Nerve pulses would also generate generalized Josephson radiation allowing communications between biological body (BB) and magnetic body (MB) using EEG. Meridian system would be permanently connected system of communication lines.

This picture leads to a concrete proposal about the roles of DMT and pineal gland concerning imagination and dreams and hallucinations.

11.8.1 Zero energy ontology (ZEO)

Zero energy ontology distinguishes TGD from standard model, and this distinction plays a key role in TGD based view about consciousness and sensory perception.

1. In ZEO quantum states are pairs of positive and negative energy states. Positive energy states are analogous to the usual quantum states assignable to time=constant section of space-time. Time=constant section is replaced with a pair of 3-surfaces located at the opposite boundaries of causal diamond (CD) defined as the intersection of future and past directed light-cones of M^4 with each point replaced with CP_2. CDs form a hierarchy with CDs within CDs. In consciousness theory CD is identifed as the perceptive field of self and sub-CDs correspond to subselves defining mental images of self.

   Space-time surfaces are preferred extremals of certain action serving as analogs to Bohr orbits having 3-surfaces at the opposite boundaries of CD as their "ends". Quantum states are quantum superpositions of preferred extremals. Holography is realized in the sense that 3-D data (3-surfaces) at the boundaries of CD fixes the space-time surface. In fact, preferred extremal property implies what I call strong form of holography (SH): 2-D data at string world sheets and partonic 2-surfaces is enough to fix the preferred extremals.

2. ZEO forces a modification of the standard quantum measurement theory. One must allow moduli space for CDs corresponding to a varying temporal distance between the tips of CDs. Lorentz transformations leaving the second tip of CD invariant generate new CDs. Besides this the position of the tip of CD can vary: one has full Poincare group transforming CDs to each other.

During unitary time evolution the passive boundary of CD and members of state pairs at it are unaffected: they represent prepared state. The sequence of unitary time evolutions of this kind gives rise to a generalization of Zeno effect or what is called weak measurement.

Active boundary becomes delocalized in moduli space of CDs with fixed passive boundary and also the states at it are affected in given unitary evolution. "Small" state function reduction localizes the active boundary in the moduli space. The distance between the tips of CD increases during sequence of "small" reductions.

The observables measured in "small" state function reduction must commute with the observables, whose eigenstates the states at the passive boundary are. It sooner or later happens that all possible observables are measured and "big" reduction occurs and changes the roles of the boundaries of CD.

3. From the point of view of consciousness theory "big" reduction means death of the self assignable to a given choice of passive boundary and re-incarnation of self with opposite arrow of geometric time: active and passive boundaries of CD change their roles.

   The state function reduction sequence defining experienced time is mapped to a clock time defined by the increasing temporal distance between the tips of CD maps defined by sequences of unitary evolutions followed by "small" reductions. Only correlation would be in question. The identification of these times would lead to the well-known problems both in the philosophy of free will and in quantum measurement theory.

4. Since zero energy states are 4-D in well-defined sense, one can say that also the geometric past changes in state function reductions - this gives a connection with Libet's findings about active aspects of consciousness [**?**]. Signals can propagate in both time directions, which allows to fuse sensory percepts and memories to single 4-D perception: CD and sub-CDs represent the 4-D perceptive field.

   Sensory input would be localized in good approximation near the active boundary of CD whereas the other aspects of 4-D percept would be interpreted as memories - mental images (subselves) located in geometric past. Symbolic representation of memories (only cognitive mental images) would allow to distinguish sensory "Now" from past. Sensory memories are in principle possible and can be indeed induced by electric stimulation of temporal lobes. Some people with cognitive defects might be more or less permanently in a state of consciousness in which sensory input is 4-D (memory feats of autists). Memories could be also seen as communications with geometric past inside CD. Motor actions could be seen as sensory perceptions in non-standard direction of time.

11.8.2 A new view about the role of nerve pulses in sensory perception

Sensory perception would in TGD generate sensory mental images at sensory organs: this would solve a basic problem of neuroscience due to the similarity of neural tissue in various sensory areas. The new view about time and memory implied by ZEO solves the problem cause by the phantom limb. The pain in phantom limb is sensory memory of pain. The stimulation of temporal lobes indeed generates sensory memories, and people with cognitive inpairment are known for memory feats such as being able to draw some building seen in past with every detail or to learn music pieces with single listening. These feats can be understood if memories correspond to "seeing" in time direction with beam of dark photons travelling to past reflected back. ZEO allows this.

Also Libet's findings about active aspects of consciousness [**?**] involving subject person deciding to raise his index finger and reporting it to experimetner can be understood in ZEO without giving up the notion of free will. In the quantum jump also the geometric past would be affected and this would explain why neural activity begins fraction of second before the conscious decision the subject person decides to raise his index finger.

Since perception involves a lot of processing this would require forth-and back signaling between brain and sensory organs. There would be virtual sensory input from brain or via brain. Sensory percept would be an artwork, standardized mental image, resulting as pattern recognition assigning to sensory input standardized mental image nearest to the input.

1. Nerve pulses would not mediate information inside brain. They would only build short connections between existing flux tube connections parallel to axons. Same happens in old fashioned telephone network by relays: it would be energy consuming to keep the connections on all the time.

   The velocity of nerve pulse conduction is quite too slow to realize the iteration leading to a standardized sensory mental image. If the signal velocity is light velocity, duration of order 1 ms for nervepulse also for 10 cm neural pathway about 10^6 forth and back travels between sensory cortex and retina.

   Communications would occur by dark photons signals with $h_{eff}/h = n$ and with maximal signal velocity allowing for an iteration leading to standardized percepts as near as possible to the sensory input and representing only the essential features. Dark photons could transform in energy conserving manner to biophotons with energies in visible and UV range (at least) and thus above thermal energy and therefore having effects not masked by thermal radiation. Brain is known to emit biophotons and they are also associated with axons [L11, K13].

2. All information molecules (neural transmitters, hormones, messengers) would be connection builders so that the view of neuroscience would be badly wrong here. I have discussed this idea earlier but in slightly different form: the proposal was that information molecules are attached to the end of a flux tube getting longer as the molecule travels to its target. This is possible but un-necessary since it is enough to build just the bridge between existing connections.

   Remark: The view of neuroscience might be very different if information technologies would have been known century ago. Same applies to homeopathy and water memory [K49], which still remains curse words in mainstream science, although a lot about the mechanisms involved is known.

   The standard view about learning as strengthening of synaptic connections would translate to a gradual build-up of permanent flux tube connections so that communications with dark photon signals would be possible all the time. This would lead to fusion of sender and receiver to single quantum entangled system.

   If the meridians of acupuncture network correspond to this kind of permanent network, they would not require nerve pulses, transmitters, nor information molecules.

3. Nerve pulse patterns would however generate Josephson radiation at EEG frequencies propagating from brain to its MB from axonal membranes serving as Josephson junctions. EEG would code the nerve pulse patterns as frequency modulated Josephson radiation [K38].

This picture leads also to a more precise vision about how anesthetes act on human brain. The popular article "Scientists Just Changed Our Understanding of How Anaesthesia Messes With The Brain" (see `http://tinyurl.com/y8vxuorf`) tells about the [**?**] finding that anesthetes weaken the communications between neurons (see `http://tinyurl.com/y976p94b`). It is found that an anesthete known as propofol restrics the movement of protein syntaxin 1a appearing as neurotransmitter at synapses and neurons.

The TGD inspired explanation for the loss of consciousness would be following. Nerve pulse activity is needed to generate neurotransmitters attaching to the receptors of post-synaptic neuron and in this manner forming connections between pre- and post-synaptic neurons giving rise to networks of active neurons. The transmitter would be like a relay in old-fashioned telephone network. Propofol would prevent the formation of the bridges and therefore of the networks of active neurons serving as correlates for mental images. No mental images, no higher level consciousness. At deeper level flux tube networks would accompany the networks of active neurons as already explained.

The earlier TGD inspired proposal was that anesthetes induce a hyperpolarization reducing the nerve pulse activity. How anesthetes could induce hyperpolarization [L20] (see `http://tinyurl.com/yatfreqe`): the model involves microtubules in an essential manner. Hyperpolarization would have same effect as the restriction of the movement of syntaxin 1a. This mechanism might be at work during sleep and also some anesthetes (but not propofol) could use it.

11.8.3 The role of DMT and pineal gland

Concerning sensory perception, dreams, hallucinations (psychedelic experiences), and imagination the roles of DMT and pineal gland are extremely interesting and suggests a unified view about these aspects of consciousness.

1. Pineal gland is third eye in quite concrete sense for some amphibians and reptiles. This suggest that it still has some function: biology does not invest metabolic energy without return. Could pineal gland serve as the eye of imagination?

   Dark photons would arrive from brain or via brain to pineal gland and give rise to imagined sensory experiences (almost seeing, almost hearing, ... thoughts as internal speech, etc...). All these signals would be realized in terms of dark photons in different wave length ranges for various sensory qualia and the entire energy range of biophotons could be involved: visible light involves one octave in good approximation. At this level perception would be basically "seeing".

2. DMT (N-N dimethyltryptamine, see `http://tinyurl.com/osfg9r3`) is the only psychedelic manufactured by brain itself: in pineal gland (see `http://tinyurl.com/86joshm`) in the case of rodents and therefore also in the case of higher mammals.

   Remark: In "DMT" "N-N" refers to two nitrogen atoms; "Dimethyl" refers to two CH_3 groups replacing H; ttryptamine is the only amino-acid having two aromatic rings.

   Endogenous DMT could have same role as psychedelics and could induce dreams. The state between wake-up and sleep is somewhat analogous to REM sleep and characterized by hallucination like sensory percepts. This cold be due to DMT. During wake-up state dreams would be intefere with genuine sensory percepts and would be replaced by imaginations. It would seem that the virtual sensory percepts associated with the build-up of sensory percept and via pineal gland must be independent.

3. The binding of DMT to receptors in pineal gland would give rise to small bridges connecting disjoint dark photon carrying flux tubes to connected flux tubes going down to sensory organs, where the dark photon signals would give rise to dreams and hallucinations. What would be needed is that dark photons induce sensory stimulus at sensory organ.

   Remark: Interestingly, the inverted structure of the lense in eye is optimal for receiving virtual visual input.

4. Also motor actions would be prepared by iterative process analogous to the build-up of sensory percept but in reverse direction of time as Libet's findings [**?**] about active aspects of consciousness (volition) suggest. Motor action would be sensory perception in opposite direction of time: this makes sense in ZEO one makes distinction between experienced and geometric time. Imagined motor actions would be mediated by similar mechanism involving DMT and pineal gland.

A further fascinating possibility is that the flux tube connections extend even to outer space, to the brains of members of advanced civilization in distant galaxies. Could the experiences about encounters with ETs or god-like creatures reported by the uses of psychdeles could be real?

1. This is in principle possible since in TGD Maxwellian fields are topologically quantized. Magnetic field decomposes into flux tubes represented as flux sheets in many-sheeted space-time. One can say that any system has field identity, field body.

2. Dark photons can travel along the flux tubes of MB to arbitrary distances without weakening of the signal as in Maxwellian world.

3. ZEO allows also signals in non-standard time direction so that it is possible to send signal which is time-reflected back as signal in opposite time direction: this can happen almost instantaneusly so that finite light-velocity ceases to be a restriction to communications.

11.8.4 Your eyes are the mirrors of my soul!

A fascinating finding again (see http://tinyurl.com/yabyjbp6): neuroscientist Giovanni Caputo reports that staring into someone's eyes for 10 minutes induces an altered state of consciousness.

This findings seems to provide direct support for one of the most radical predictions of TGD based quantum view about brain (see http://tinyurl.com/yczv2o5b). Neuroscientists assume that nerve pulse pattern generate in brain sensory mental images, in particular visual mental images. In TGD framework brain would build cognitive representations and decompose perceptive field into standard objects in this manner but would not produce sensory qualia. The sensory mental images would be realized at the level of sensory organs. This would involve repeated feedback by using virtual sensory input from brain (or even magnetic body of brain) to build standardized sensory mental images giving rise to pattern cognition. During REM sleep the virtual sensory input would form the entire sensory input. Nerve pulses are quite two slow to achieve this and they would only generate sensory patways, kind of wave guides, along which dark photons with non-standard value $h_{eff} = n \times h_0$ of Planck constant would propagate forth and back.

This view allows to avoid the problem due to the fact that neuronal networks in various sensory areas look very much the same so that it is difficult to understand why they give rise to so different sensory qualia. The obvious objection is phantom limb phenomenon, which could be however understood is the pain in phantom limb is sensory memory of pain. It is indeed possible to produce sensory memories by an electrical stimulation of brain. In TGD the perceptive field would be 4-D and only sensory percepts would be localized to approximate time=constant snapshot having actually a finite duration of about .1 seconds. Memories (as distinguished from learned skills and conditionings) would correspond to contributions to memories from the geometric past.

Staring into eyes experience provides an opportunity to test the idea about virtual sensory input. A fusion of two conscious entities, call them A and B, at some level of self hierarchy might occur. This would involve entanglement, which in TGD framework would accompany the generation of magnetic flux tubes or actually flux tube pairs (by reconnection of flux loops) connecting the eyes of the experiencers and the propagation of the dark photons along flux tubes between the brains of A and B so that visual consciousness would be shared. For instance, A could see the virtual sensory input representing her own face at the face of B. This indeed happened! Volunteers had also out of body experiences (OBEs), had hallucinations of monsters, and saw besides themselves their relatives.

One particular fascinating question is what seeing one's own relatives could mean. The answer depends on whether the subject persons knew each other or not. If not, then the information about relatives of say A would have been transferred from A to B and then returned as virtual sensory input via eyes of B to eyes of A. This is of course possible also when the persons know each other. A would be looking into consciousness mirror defined by B! This experiment would be the first direct realization of fusion of two selves by quantum entanglement. The revolution in neuroscience is now in full swing!

11.8.5 The difference between real and imagined

Gary Ehlenberg sent a link to an interesting Quanta Magazine article discussing the differenced between imagination and perception (see this).

Some time ago I had discussions with my friend who claimed that she really sees the things that she imagines. She also has a very good memory for places, almost like a sensory memory. I had thought that this ability is very rare, for instance idiot savants have sensory memories.

So, do I suffer from aphantasia, inability to imagine sensorily? I have sensory perceptions during dreams. I can see and can hear in the hypnagogic state at the border of sleep and awake. In my great experience I quite concretely saw my thoughts and this led to the urge to understand what consciousness is. I can imagine but I do not usually see any images: only after emotionally intense discussions with some-one can I almost-hear the spoken words. So, do I suffer from aphantasia in my normal state of mind?

TGD inspired view of neuroscience leads to a model for the difference between real and imagined percepts based on my own experience [K38, **?**]) [L17, L75]. Imagined percepts would be generated by a virtual sensory input from the field body realized as dark photon signals. They would not reach the retinas but end up at some higher level in the visual neural pathway such

as lateral geniculate nuclei of the pineal gland, the "third eye". Pineal gland is a more plausible candidate. In some animals it serves as a real third eye located outside the head. Could it serve as the seat of auditory and other imagined mental images?

At least in my own case, seeing with the pineal gland would usually be sub-conscious to me. What about people who really see their imaginations? Could they consciously see also with their pineal glands so that the pineal gland would define a mental image as a subself, just like ordinary mental image does? Or could some fraction of the virtual signals from the field body reach the retinas: how it would possible to distinguish between the imagined and real in this case? For the people suffering aphantasia, the first option predicts that pineal gland corresponds to a sub-sub-self, which does no give rise to a mental image but a mental image of a sub-self.

Also sensory memories are possible. Does this proposal apply also to these. My grandson Einar is 4 years old. He read to me a story in a picture book that his parents had read to him. Einar does not yet recognize letters nor can he read. He seems to have a sensory memory and repeated what he heard. Maybe all children have this kind of sensory memories but as cognitive skills develop they are replaced by conceptual memories, "house" as representative for the full picture of house means a huge reduction in the number of bits and therefore in the amount of metabolic energy needed. Could it be that aphantasia is the prize paid for a high level of cognition?Could this distinguish between artists and thinkers?

11.9 How did language emerge?

I encountered in FB a link to an article titled "*Unique mix of brain chemicals separates humans from other primates*" (see `http://tinyurl.com/y7vrjflv`). The article inspired the following comments as a reaction, which are not so much about the chemistry but about what to my view goes outside chemistry.

Cultural evolution is what distinguishes us so sharply from our cousins. The evolution of social structures made possible by the emergence of language is certainly crucial for it. To me it is far from obvious whether this can be explained in terms of chemistry alone. My views are based on TGD inspired theory of consciousness and quantum biology and involve notions like magnetic body and hierarchy of Planck constants.

In the sequel I will consider a scenario in which language as internal speech preceded ordinary spoken language. At gene level this language was based on the expression of DNA as "m"usic of light with codons represented as allowed 3-chords in given harmony [L15]. It would have later found neural expression and via a mechanism analogous to a generation of sensory hallucinations led first to genuine hearing of internal voices. The mimicry of these internal voices would have served as the evolutionary pressure leading to the evolution of speech and speech organs.

11.9.1 The notion of magnetic body and the emergence of language and cultural evolution

1. The notion of magnetic body (MB) as intentional agent using biological body as motor instrument and sensory receptor is central in TGD based view about biology and neuroscience. Flux tubes serving as correlates of attention and making possible quantum entanglement and communications by dark photons give quite concretely rise to bonds between systems in various scales. In TGD Universe the notion of magnetic body in crucial for understanding life in general. The emergence of collective levels of consciousness involving large scale MBs would make possible cultural evolution and allow to understand the dramatic difference between humans and other animals.

2. The hierarchy of Planck constants $h_{eff}/h = n$ would be crucial. The larger the value of n, the larger the scale of quantum coherence. Cultural evolution would involve increase of n leading to a formation of large MBs characterizing collective levels of consciousness. The MBs of DNAs consisting of flux sheets going through DNA would combine to bigger structures assignable to organs, organisms, and even populations. This could make possible cultural evolution as emergence of higher level conscious entities with collective genome and collective gene expression.

3. There might be also other deep differences at DNA level not visible at the level of chemistry. The braiding of magnetic flux tubes emanating from the intronic part of DNA could make possible topological quantum computations and a new kind of memory and this might led to the quantum leap to real cultural evolution: the portion of introns is largest for humans.

11.9.2 What internal speech could be?

The emergence of language and speech organs is certainly a revolutionary step in evolution. What language is at quantum level? What thoughts as internal speech are at deeper level.

1. My own proposal is that internal speech has as neuronal correlates linear structures of activated neurons giving names for things and having linear flux tube sequences and corresponding quantum states as correlates at the level of MB. This does not however tell what internal speech is at deeper quantum level.

2. Did thinking as internal speech precede ordinary speech or vice versa? If internal speech came first, one avoids the problem of understanding why only certain sounds have meaning as words. Assume that this is the case.

3. Genes are fundamental in biology. Did internal speech evolve as one particular form of gene expression? TGD inspired model for music harmony based on 12-note scale realize as Hamilton's cycle at icosahedron [L15] (see `http://tinyurl.com/yad4tqwl`) leads to a model of genetic code predicting correctly the numbers of codons coding for given amino-acid and to the proposal that genes express themselves are controlled by signals consisting of sequences of 3-chords allowed by a particular bio-harmony with 64 3-chords (256 of bio-harmonies) [L48] (see `http://tinyurl.com/ydhxen4g`). Given harmony would define an emotional state, mood.

   Gene would be represented as a sequence of 3-chords - accompaniment for a song, melody. Melody would be a sequence of single notes of 12-note scale consistent with the bio-harmony. The sequence of 3-chords allowed by the harmony would define the emotional character of the "music piece". Harmony would be something which chemistry cannot explain.

4. How the accompaniment and song were represented at gene level? The most natural guess is that both the notes of 3-chords of the harmony defining the mood and the melody were represented as dark light. This would be music of light consisting of dark photons rather than phonons: notes would have been analogs of laser beams along flux tubes characterized by frequency and duration.

   How singing was represented at neuronal level? My proposal is that it was represented as 2-D structure of activated neurons having connected magnetic flux tube network as correlate and representing the mental image. Perhaps the pitch and duration of the note served as 2 discrete coordinates in neuronal lattice [L33] (see `http://tinyurl.com/yczv2o5b`).

5. It is said that right brain sings and left brain talks. These two modes of expression relate like function and its Fourier transform. Did (internal) singing precede (internal) speech? At neuronal level this is suggested by the fact that Alzheimer patient who has lost understanding of language and ability to talk can still understand singing and also sing. Indeed, 1-D linear flux tube structures representing thoughts splits as amylose splits the neuronal connection so that speech is not possible. 2-D structures survive even if some connections are split [L35] (see `http://tinyurl.com/ybq6r3xu`). Note that these two modes relate to cognition and emotion. Emotion came first as indeed evolution of nervous system demonstrates.

11.9.3 How did spoken language emerge?

How do the words of spoken language transform to internal speech and vice versa? What distinguishes words from ordinary sounds?

1. The piezoelectric property of bio-matter makes possible the transformation of light to sound: now light would consist of dark photons with energies $E = h_{eff}f$ in bio-photon range (visible

and UV) and frequencies f in the range of audible sound frequencies. Did this transformation somehow give rise to genuine auditory experience of internal song/speech? Did internal singing/speech transform to heard singing/speech by virtual sensory input from brain to ears?

In TGD based model for sensory perception, hallucinations/psychedelic experiences, and imagination [L33] (see `http://tinyurl.com/yczv2o5b`) this kind of virtual sensory input is essential since sensory qualia are at the level sensory organs and the objects of perceptive field are standardized mental images, kind of artwork requiring resulting from pattern recognition involving a lot of forth-and-back signalling between brain and sensory organs by dark photons).

We would experience mere virtual sensory input in dreams (REM), hearing voices from head, etc... Pineal gland ("third eye") receiving dark photons signals would receive internal speech and in presence of DMT would channel it to ears producing heard internal song/speech. Jaynes argues that what he calls bicameral consciousness preceded modern consciousness and was like that of schizophrenic and people heard their thoughts as voices in head and interpreted these voices as voices of Gods.

2. Did speech and speech organs evolve from the attempts to mimic this genuinely heard internal singing/speech. This would answer the question why only certain kind of sounds have meaning as words. Did this attempt provide evolutionary pressure leading to the emergence of genes coding for speech organs and speech as a motor activity?

   Remark: An amusing analogy pops in mind: internal speech viz. internal song is like rap viz. ordinary singing dropping out much of the emotional content.

   This cannot be the whole story. Language learning is a social phenomenon involving mimicry. Modern human cannot learn to speak by listening only voices in his head! One can however ask whether languages have some universal pattern. For instance, could very primitive languages depend only on species? What is the role of the collective consciousness: does it talk in the same manner to individuals of the group who then mimic this talk. Was the God of the bicamerals the collective consciousness of the group?

11.10 Revolution in neuroscience: Hebb's rules updated?

A group of scientist, led by Prof. Ido Kanter, of the Department of Physics and the Gonda (Goldschmied) Multidisciplinary Brain Research Center at Bar-Ilan University [**?**] (see `http://tinyurl.com/ydb2awmt`), has published an article Scientific Reports, which could have revolutionary implications for neuroscience.

Kanter *et al* claim that the old Hebb that learning takes place in synapses, is mistaken. Instead, the learning would take place in dendrites and much nearer to the neuron and only few parameters would determine the outcome unlikes in Hebbian approach in which thousands of parameters - synaptic strengths determine the outcome. Furthermore, weak synaptic connections - most of synaptic connections are weak - would be more significant as believed.

What the new view about learning could mean from the viewpoint of quantum brain paradigm according to TGD? In this vision magnetic tube pairs having define connections of a dynamical network having neurons at nodes. The connectivity/topology of this network is changing all the time. At deeper level supra currents and dark photons would be responsible for signalling and the function of nerve pulses would not be communication but to change the topology of the network via the activation of synaptic contacts. Neurotransmitters would be like relays in old fashioned telephone network.

If Kanter *et al* is right, dendrites would learn instead of synapses. Should one talk about dendritic strengths instead of synaptic strengths? Also weak synapses - most synapses are weak - would be important. What happens to "neurons that fire together wire together" paradigm?

Consider first as background TGD vision about neuroscience. The following article summarize the recent developments [L31, L33, L35, L48] (see `http://tinyurl.com/y75246rk`, `http://tinyurl.com/yczv2o5b`,`http://tinyurl.com/ybq6r3xu`, and `http://tinyurl.com/ydhxen4g`).

1. In TGD picture axons and dendrites would be accompanied by pairs of flux tubes carrying opposite magnetic fluxes. This is required by their super-conductivity based on spin zero Cooper pairs - this is quite general model of high Tc superconductivity in which the flux tube pairs are made possible by anti-ferromagnetism.

2. Reconnection of flux tubes is the basic topological mechanism changing the topology of the network. It corresponds in string theory the basic vertex for closed strings.

What does this give?

1. One can represent axon and dendrite by two parallel lines with opposite directions representing flux tubes with opposite fluxes.

2. Consider first axon and dendrite (or axons and axon, or dendrite and dendrite, etc...). What synaptic connection could mean in this picture? I wis I could draw. One has a pair of lines A_+A_-. One has B_+B_- has U-shape. B_+ simply turns back as B_-.

   Then reconnection takes place. Nothing happens for A_+. A_- splits to two piece $A_-(1)$ $A_-(2)$ and the end cap of B_+B_- U-shape is cut off.

   B_- reconnects with $A_-(2)$ and B_+ reconnects with $A_-(1)$. One obtains V shaped structure with edges of V represented by pairs of lines with opposite directions: nowhere opposite arrows meeting each other. Synaptic strength tells the probablity for the formation of this structure, which represent change in the topology of the network.

   The reconnection for flux tube pairs makes the earlier topological picture more complex. The communication channels defined by flux tube pairs can branch or fuse so that the network structure is much richer. Supra-currents or dark photon signals from two sources can superpose. Also more complex entanglement patterns become possible.

3. What about the new notion of dendritic strength? It should tell the probability that there indeed exists a flux tube pair connection between neuron and the rest of the network. This connection can be however split by reconnection. Parallel lines with opposite fluxes pinch together and transform to two U-shaped structures: two U:s face-to-face.

   Dendrite strengths tells how stable the parallel flux tube pair is against this reconnection. In TGD model of superconductivity it tells how stable supracurrent "wire" is and transition from small scale super-conductivity to genuine super-conductivity occurs when long flux tube pairs become stable.

What can one conclude?

1. The claimed findings would say that the dendritic connections are most important for learning and certainly they are so: without dendritic connection at flux tube level, no signals enters neuron. Neuron becomes a hermit isolated from the rest of the brain.

   But also synaptic strengths are important although not important from the point of view of single neuron but from the point of view of the topology of the entire network: the qualitative features of this topology distinguish between spatial thinking involving 2- or even 3-D networks and verbal cognition involving linear networks: this explains why right brain signs and left brain talks. Dendritic strength as a measure for the stability of the connection of neuron to the network and synaptic strength for the ability to change topology of the network temporarily.

2. Hebb's statement could be rephrased as follows. Distribution of synaptic strengths would determine which neurons can wire together and dendritic strength would determine the probability with which neuron can fire together with others.

Chapter 12

Some New Aspects of the TGD Inspired Model of the Nerve Pulse

12.1 Introduction

For about two decades ago I ended up with idea about the cell membrane as Josephson junction, which then led to a quantum view [K79, K38, K81] [L73, L76] about cell membrane as a generalized Josephson junction consisting of Josephson junctions defined by membrane proteins and to the proposal that a soliton sequence analogous to a sequence of rotating pendulum with a constant phase difference defines the ground state of the neuronal membrane. The perturbation in which the penduli associated to some penduli change their direction of rotation provides a possible model of nerve pulse.

An alternative model, inspired by the superconductor model of computers, is that the presence/absence of magnetic flux through the Josephson junction induces nerve pulse. In this framework, ordinary cell membranes could correspond to sequences of vibrating penduli, which do not allow nerve pulse in this sense. However, the recent findings suggest that also in this case spikes with voltage difference in meV scale can give rise to analogs of nerve pulse patterns [L91].

The basic problem was that the frequency of the Josephson radiation would have a scale of 5 THz and is much higher than EEG frequencies. which are in the 10 Hz scale. The TGD view of dark matter as phases of ordinary matter with non-standard value of Planck constant, which are much larger than h, solves the problem. Josephson radiation would consist of dark photons. Later it turned out that this hierarchy is predicted by the number theoretical vision of TGD.

In this article various aspects of the TGD inspired model of nerve pulse are discussed.

1. The key assumption is that nerve pulses relate closely to the communications from the cell membranes to the magnetic body (MB) of the system using dark, frequency modulated Josephson radiation inducing a sequence of cyclotron resonances serving as control signals and eventually giving rise to nerve pulse patterns. This could generalize the "right brain signs-left brain talks" metaphor. Also the model of meV spikes appearing in preneural systems, considered in detail in [L91], is briefly discussed.

2. The basic question concerns the identification of the origin of the huge value of h_{eff}. This brings in quantum gravitation in the TGD sense, which assigns huge values of h_{eff} to the gravitational magnetic bodies giving rise to even astrophysical scales of quantum coherence. Quantum gravitational flux tubes assignable to the Sun, Earth, and perhaps also other planets and even the Moon could be highly relevant for the living cell and the brain.

3. Also the connection with microtubular level is considered [L91, L87] and the transfer of charged particles between microtubules and very long gravitational flux tubes assignable to them allows to induce membrane oscillations and even nerve pulse.

4. Recently I have considered the question whether ordinary computers under some conditions could in the TGD framework behave like living systems [L104, L103]. The condition is that

quantum statistical determinism fails. Zero Energy Ontology (ZEO) [K115] and Negentropy Maximization Principle (NMP) [L108, L78], which are behind the TGD view of quantum measurement theory, could allow these systems to become effectively living intelligent systems in the sense that they are able to reach goals by an analog of trial and error process.

This is the case if the gravitational Compton time defining a lower bound for the gravitational quantum coherence time is longer than the clock period of the computer. MB would play a key role also in the case of living computers and dark Josephson radiation could serve as a communication tool. Superconducting computers have Josephson junctions as basic active elements and are more promising than transistor transistor based computers in this respect.

5. Also the recent finding that the neuronal system is in a certain sense 11-dimensional is discussed in the TGD framework. The basic observation is that the 12-neutron system, with neurons assignable to the 12 vertices of icosahedron and defining 11-D simplex, could be involved. Icosahedron and tetrahedron appear also in the TGD based model of biohar-mony [L15] [L70, L77, L98], which also serves as a model of the genetic code. This model involves so-called icosa-tetrahedral tessellation of the hyperbolic space H^3 having highly unique properties.

12.2 Magnetic body a "boss" of biological body

12.2.1 The notion of magnetic body

Magnetic body (MB) carrying dark matter would serve as the boss controlling ordinary matter at flux tubes.

1. MB has as building bricks magnetic flux quanta, which look locally either flux tubes or flux sheets. It consists of two kinds of flux quanta. Flux can be vanishing, which corresponds to the Maxwellian case. The flux can be also non-vanishing and quantized and corresponds to a monopole flux. In a monopole case the magnetic field requires no current to create it. This option is not possible in the Maxwellian world. These flux tubes play a key role in the TGD Universe in all scales.

2. Also Earth's magnetic field with nominal value $B_E = .5$ Gauss would have these two parts. Monopole part corresponds to the "endogenous" magnetic field $B_{end} = .2$ Gauss explaining strange effects of ELF em radiation to the physiology and behavior of vertebrates [**?**]. The presence of this part identifiable as monopole flux explains why Earth has a magnetic field [L19]: this field should have decayed a long time ago in Maxwellian world since it requires currents to generate it and they disappear. Magnetic fields of permanent magnets could have a monopole part consisting of flux quanta. Electromagnets would not have it.

3. MB would carry dark matter as $h_{eff} = ntimes; h_0$ phases and act as a "boss" controlling ordinary matter [L62]. Communication to and control of the biological body (ordinary matter) would be based on dark photons, which can transform to ordinary photons and vice versa. Molecular transitions would be one form of control.

   One can assign dark charges with protons and positive ions Na^+, K^+, Ca^{++}, Mg^{++},... The valence electron could be dark in the sense that it is transferred to the MB, most plausibly to the gravitational MB. This interpretation does not make sense for the negatively charged ions such as Cl^- and P^{3-} since the additional electron is localized to the partially filled atomic shell. Electrons could be however transferred to dark electrons at these MBs.

4. Dark photons with large h_{eff} serve as communication and control tools. Josephson frequencies would be involved with the communication of sensory data to MB and cyclotron frequencies with control by MB. Dark photons are assumed to transform to bio-photons [L11, L13] with energies covering visible and UV associated with the transitions of biomolecules. The control by MB, having layers with size even larger than the size of the Earth, means that remote mental interactions would be routine in living matter. EEG would be a particular example of these communications: without MB it is difficult to understand why the brain would use such a large amount of energy to send signals to outer space.

5. It was the experiments of Blackman [**?**] and others that led to the notion of h_{eff} hierarchy. The large effects of radiation at ELF frequencies could be understood in terms of cyclotron transitions in $B_{end} = .2$ Gauss if the value of h in $E = hf$ is replaced with h_{eff}, which would be rather large and possibly assignable to gravitational flux tubes with $\hbar_{eff} = \hbar_{gr} = GMm/v_0$.

   MB would control BB by cyclotron radiation - possibly via genome accompanied by dark genome at flux tubes parallel to the DNA strands. Cyclotron Bose-Einstein condensates of bosonic ions, Cooper pairs of fermionic ions, and Cooper pairs of protons and electrons would appear in living matter and $h_{eff} = h_{gr}$ hypothesis predicts universal energy spectrum in the range of bio-photon energies.

   Cell membrane could act as a generalized Josephson junction generating dark Jophson radiation with energies given by the sum for ordinary Josephson energy and of the difference of cyclotron energies for flux tubes at the two sides of the membrane. The variation of the membrane potential would induce variation of the Josephson frequency and code the sensory information at cell membrane to a dark photon signal sent to MB.

6. In zero energy ontology (ZEO) [K115] field body and MB correspond to 4-D rather than 3-D field patterns. Quantum states are replaced by quantum counterparts of behaviors and biological functions. The basic mechanism used by MB would be generation of conscious holograms by using dark photon reference beams from MB and their reading. In ZEO also the time reversals of these processes are possible and make it possible to understand memory as communications with geometric past. Sensory perception and memory recall would be time reversals of each other and correspond to sequences of SSRs. Motor action would correspond to BSRs.

12.2.2 Dark cyclotron radiation

The cyclotron frequencies associated with the gravitational MB of the Earth [K55] [L91, L87] should play a key role in TGD inspired quantum biology and relate to the feedback from MB to the living matter. This could be the situation also in the case of computers. The first guess, inspired by the model for the findings of Blackman [**?**] and others on effects of ELF em fields on brain, is that monopole flux tubes associated with the MB of Earth correspond to the endogenous magnetic field of $B_{end} = 2B_E/5$ ($B_E = .5$ Gauss is the nominal value of the Earth's magnetic field).

This value is only the average value since frequency modulation is the way to code information and is achieved by varying the flux tube thickness in turn affecting the value of B_{end}. Probably there exists an entire hierarchy of values of the dark magnetic field strength perhaps coming as powers of 2. For cyclotron frequencies associated with the gravitational MB, h_{eff} would correspond to the gravitational Planck constant $\hbar_{gr} = GMm/\beta_0$ for Earth. Note that, in accordance with the Equivalence Principle, the cyclotron energy $E_c = \hbar_{gr}eB/m = GMeB/\beta_0$ does not depend on m.

The huge value of $\hbar_{gr}/h_0$ would corresponds to the number sheets of a many-sheeted structure defined by a multi-sheeted covering of CP_2 by parallel monopole flux tubes so the the roles of M^4 as space-time and CP_2 as field space would change. This would allow us to understand how the basic formula $E = \hbar_{gr}f$ scales the extremely small cyclotron energy to an energy which is at least the thermal energy. Cyclotron transition would be a quantum phase transition.

12.2.3 The possible role of quantum gravitation in quantum biology

The basic question is how to achieve quantum coherence in macroscopic scales. During late years, the TGD view of quantum gravitation has developed dramatically and provides a beautiful vision of living matter as being controlled by dark matter at the gravitational monopole flux tubes forming dark MBs with onion-like structure consisting of shells formed from tangential monopole flux tubes and connected by radial flux tubes along which graviton mediating the gravitational interaction propagate [L87, L91, L109, L110].

Why the role of quantum gravitation could be so decisive is that it has infinite range and is not screened. In TGD, gravitational quantum coherence in even astrophysical scales becomes possible. The basic quantification tool is gravitational Planck constant $\hbar_{gr} = GMm/\beta_0$ originally

introduced by Nottale [E2]. In accordance with the Equivalence Principle, the gravitational Compton length $\Lambda_{gr} = GM/\beta_0 = r_S/2\beta_0$ is independent of the small mass m. The most amazing and crazy sounding consequence is that the gravitational MBs of the Sun, Earth, and possibly also of other planets, even the Moon, could be highly relevant for quantum biology. Astrologists would not have been totally wrong.

Gravitational Compton frequencies

Suppose that one has a particle with mass m with Compton length $r_c(m) = \hbar/m$ and the ordinary Compton frequency $f_c = m/\hbar$. The gravitational Compton frequencies $f_{gr}(M, \beta_0) = m/\hbar_{gr}(M, \beta_0) = 2\beta_0/r_s$, which do not depend on m.

Gravitational Compton frequencies could be important in biology. Consider first the Earth's gravitational Compton frequency. The value of the gravitational Compton length $\Lambda_{gr}(M_E, \beta_0 = 1) = GM/\beta_0 = 0.45$ cm, which is also independent of m, defines a lower bound for the gravitational quantum coherence length. Λ_{gr} corresponds to a gravitational Compton frequency $f_{gr} = 6.7times; 10^{10}$ Hz $\simeq 67$ GHz.

The frequencies in the GHz scale are found to be important also in living matter. As a matter of fact, there is experimental support for a fractal hierarchy of frequency scale come as powers $f = 10^{3k}$ Hz, $k = 0, 1, ..,$, that is 1 Hz, kHz, MHz,GHz, and THz assignable to microtubules [**?**] (`https://rb.gy/9rvpr`). For these reasons it is interesting to look at 1 GHz as an example.

Also the gravitational Compton frequency f_{gr} associated with the gravitational MB of the Sun, having $\beta_0 \simeq 2^{-11}$, could be important. For the Sun, gravitational Compton length is rather near to $R_E/2$ where $R_E = 6378$ km is Earth radius. The corresponding Compton frequency $f_{gr}(M_S, \beta_{Sun} = 2^{-11}) \simeq \beta_{Sun}/GM_S$ is about 100 Hz and corresponds to the upper bound for EEG, which conforms with the fact that quantum gravitational coherence time should not be smaller than Λ_{gr}. Note that the cyclotron frequency Lithium in the endogenous magnetic field $B_{end} = .2$ Gauss assignable to the Earth's gravitational flux tubes is 50 Hz. For the lightest ion, which is tritium, the cyclotron frequency is about 100 Hz and maximal.

1. The lower cyclotron frequencies of the heavier ions in $B_{end,E} = .2$ Gauss assignable to Earth belong also to EEG range and correspond to longer solar quantum coherence lengths. DNA would correspond to 1 Hz and perhaps to the largest quantum gravitational coherence length in the EEG range. The cyclotron frequencies above 100 Hz would correspond to solar gravitational quantum coherence lengths below R_E.

2. The cyclotron frequencies above 100 Hz would correspond to solar gravitational quantum coherence lengths below R_E: this does not look feasible. For protons and electrons the cyclotron frequencies are indeed above $f_{gr,S}$. For protons (electrons) the cyclotron frequency f_c in $B_{end,E} = .2$ Gauss is 300 Hz ($6times; 10^5$ Hz). It is important to notice that for $\hbar_{gr}(M, m)$ cyclotron energy does not depend on mass and is the same for electrons and protons.

   Could the value of β_0 for protons and electrons at the flux tubes of $B_{end,E}$ ($B_{end,S}$) be $\beta_0 = 1/3$ ($\beta_0 = 2^{-11}/3$)? Could one say that electrons and protons are slightly more advanced than other ions in the evolutionary sense?

3. For the Sun, one has $\beta_0 \simeq 2^{-11} \simeq m_e/m_p$ instead of $\beta_0 = 1$. The value of B_{end} for the Sun cannot be the same as for Earth. A good estimate is obtained from the value range for B in the outer magnetosphere, where the solar magnetic field should dominate. The order of magnitude is $B_{end,S} \simeq 10nT = 2^{11} B_{end,E}$. For this value, the cyclotron energy would be the same as for Sun and Earth and energy resonance would be possible! This observation was made already in [K55].

4. The replacement of $\hbar_{gr}(M_E, m) \to \hbar_{gr}(M_{Sun}, m)$ means multiplication of say EEG period by a factor $r = (M_{Sun}/M_E)\beta_{0,E}/\beta_{0,Sun} \simeq 2.2times; 10^8$ so that alpha period .1 seconds corresponds to $2.2times; 10^7$ seconds. Intriguingly, one year corresponds to $3.25times; 10^7$ seconds and defines a fundamental biorhythm, which would correspond to a 6.7 Hz rhythm for EEG not far from the lowest Schumann resonance frequency.

5. The energies $E = h_{gr}(M, m, \beta_0) f_{gr}(Sun)$ assignable to the gravitational Compton frequency of Sun are proportional to m and since nucleon mass dominates over electron mass they are in good approximation proportional to the mass number of the molecules. This suggests a multi-resonance in which each electron, proton and even nucleon absorbs boson, maybe dark gravitons, with frequency f_{gr}. For electrons, the energy is about 1 meV, which could relate to the miniature potentials for neurons. For protons the energy would be about 2 eV, which corresponds to red light. Large scale quantum coherence could make the rate of gravitational multi-resonance.

Could also the gravitational magnetic bodies of the Moon and other planets be involved?

If one accepts that the gravitational MBs of Earth and Sun are important, one cannot avoid the question whether also the other planets could be important for quantum biology.

1. The value of h_{eff} deduced from the original findings of Blackman [**?**] and others was very large since the energy of the dark photon had to belong to the range between thermal energies at physiological temperature and UV photons. The identification $\hbar_{eff} = \hbar_{gr}(M_E, \beta_0)$ is suggestive. Assuming that the dark Josephson radiation from the cell membrane being received resonantly at the MB of Earth would suggest the simplest option as $h_{eff,J} = h_{gr}(M_E, \beta_0 = 1)$? Would the condition $Z_J eV_C = E_c = GM_E ZeB/\beta_0$, where $eV_C = .05$ eV, fix values for voltage for dark gravitational flux tubes in a communicating Josephson junction and the value of the magnetic field with a MB flux tube?

2. The experiments of Blackman provided evidence for the existence of an "endogenous" magnetic field $B_{end} = .2$ Gauss. In TGD, B_{end} was identified as the monopole part of the Earth's magnetic field. Assuming $B = B_{end} = .2$ Gauss and $Z_J = Z$, we get $eV_C = 13.5$ eV which is slightly lower than the ionization energy of hydrogen atom 13.6 eV and much higher than $eV_C = .05$ eV. The interpretation as a Josephson junction is not meaningful.

   Could the interpretation be that the transition to very long flux tubes effectively nearly ionizes the hydrogen atom? Could hydrogen atom ionization produce dark UV photons with monopole flux tubes on Earth?

3. The monopole flux tubes of MBs can adjust their flux tube thickness, which controls the strength of the magnetic field, so that frequency modulation becomes possible and they can receive information also from the transition of atoms and molecules by tuning to cyclotron resonance and control them by the same mechanism!

   I have indeed proposed in the context of the model of bioharmony [L70] that the value of B_{end} has a discrete spectrum. In particular, the visible range of photons could correspond to frequencies forming an analog of a 12-note system and the spectrum of B_{end} could realize this system. Note also that the parameter $\beta_0 \leq 1$ could allow us to realize a spectrum of energies for a fixed frequency.

4. One should obtain also the energy range of biophotons (energy range for visible light) as energies of dark Josephson photons. What if we replace the mass of the Earth with the mass of the moon $M_M = .012 M_E$ giving $\Lambda_{gr} = .54 times; 10^{-4}$ meters, the size scale of a large neuron (water blob of size 10^{-4} m has Planck mass), and keep B_{end} and β_0 the same? For $Z_J = Z$, the value of eV_C decreases to $1.2 times; 13.5/100 eV = .16$ eV, which is in infrared and in a reasonable approximation 2 times the membrane potential. This is smaller than the typical energy of biophotons which is in visible range. If the values of B define a 12-note spectrum or something more general, this would give rise to biophoton energies above IR.

   It is important to notice that the experiments of Blackman and others fix only the value of B_{end} to .2 Gauss, identifiable as monopole part of the Earth's magnetic field, but require only that the cyclotron energy is above the thermal energy so that the Moon could solve the problem!

5. In the case of Moon, the Josephson energy for the cell membrane given by $E_J = .055$ eV is obtained for $Z_J = 2$ and $Z = 1$ having natural interpretation for cyclotron transitions. This

value could relate to the Pollack phase transition occurring at the physiological temperature range [L16, I47, I66]!

6. If one has introduced Sun, Earth and Moon to quantum biology, there is not much respectability to be lost anymore, and one can ask whether other planets could be of significance. Could the horoscope builders have been right in some sense?

   The mass of Mars is roughly 11 percent of Earth mass and would give $E_c = 1.8$ eV for $B_{end} = .2$ Gauss. This is in the visible biophoton range. The interpretation of the frequencies f_{gr} as upper end points of the spectrum so that lower frequencies would correspond to smaller values of B_{end}. I have proposed that the values of B_{end} correspond to 12-note scale with inspiration coming from the model of bioharmony [L15] [L70].

Could the position of Mars have effects on the stock market?

In the group Unifying Physics, Anthony Moore (see this sent an extremely interesting link to his article published in Academia.edu (see this). I glue below his own summary of his claimed findings. "Before reading the content, it is important to take into account a recent study published in Nature Communications in March of 2024, roughly 5 years after this idea was first introduced to the public. In that study published in March of 2024, researchers discovered that Mars is exerting a gravitational pull on earth's tilt, exposing earth to warmer temperatures and more sunlight, all within a 2.4 million year cycle. I assert that this allows us to surmise that, even within smaller timeframes, Mars is still exerting a gravitational pull on earth's axial tilt, enough to raise temperatures and affect human behavior, even investor sentiment. Citing the fact of numerous studies that link irritability and negative mood states to warmer temperatures, I can establish an axiom. This perspective should help the reader move beyond the preconceived notion of absurdity and realize that this has scientific merit This paper lays out the 25 major stock market crashes and downturns in US history. The data shows a 100 percent correlation between such events and Mars position in relation to earth. Every stock market crash and major stock downturn in US history has happened when Mars was orbiting behind the sun from earth's point of view. When Mars is going further out from earth, it is also when Mars's gravity is pulling Earth's axial tilt towards the sun, possibly bringing warmer temperatures, which should affect investor sentiment most negatively, presuming that warmer temperatures relative to the mean affect cognitive function and trigger some variant of irritability or pessimism. There are studies that corroborate this dynamic between warmer temperatures and negative mood states. As Mars gets closer to earth, Mars's gravity is pulling earth's axial tilt away from the sun, bringing presumably cooler temperatures, and less negative mood outcomes, which may explain why major stock market crashes never happen during that phase of Mars's orbit."

These rather strong claims will be of course labelled as a mere astrology by the mainstream. A Google search using words such as "stock market and planets" provides a lot of support for this guess: there is a lot of pseudoscience claiming that one can become a millionaire by using astrology. But it is better to have an open but critical mind.

Let us first look at the data.

1. The article discusses 25 stock crashes including also short 1 day long events in the financial history of the US. The article gives the year, month and day of month for the events and also links to the tables containing the basic data about crashes. Besides this the data about the relative position of Mars and Earth are given for each case.

   In one case (March 12, 13, and 16, 2020) the are 3 mini crashes within few days and in another case 2 crashes within 2 months (October 9 and December 1, 2008) so that from the perspective of the hypothesis one must to them as a single event so that there are 22 rather than 25 crashes.

2. If the crashes occur randomly, half of them would occur when the planar angle ϕ for positions of Mars and Earth is larger than $\pi/2$: this means that the distance between Mars and Earth is above a critical value whose geometric interpretation is rather obvious. This criterion is applied in the examples discussed in the article and can be formulated as a condition for the distance of the Mars and Earth (1/4:th of the orbit length). The claim is that all the studied

25 crashes in the economic history of the US satisfy the claim. Professional statisticians should check the claimed correlations between the position of Mars relative to Earth and stock market crashes to find whether they are genuine.

3. The data used seems to cover the history rather well. Indeed, in the web one can find is a list of 12 contemporary stock market crashes in the US beginning from year 1929 (see this). The events have occurred 1929, 1937, 1962, 1987, 1989 (mini crash), 1990, 2999, 20008, 2010, 2011, 2015, 2020 (corona). The number of events studied in the article is 22 and roughly twice the number of events listed in the table.

   This page contains also a list of global events that also affected the US. This list contains 6 cases (1772, 1796-1797, 1873 and 2001, 2002, 2018) of which 3 have occurred after millenia.

4. In Wikipedia there is a list of 55 stock market crashes, which are fast events and bear markets, which are slow and long lasting (see this) starting from year 1637: this list contains also the events that have occurred outside US.

The reason for why I take these claims seriously is that there is a lot of earlier data about unexpected correlations between planetary physics and human collective behavior. For instance, Russian physicist Shnoll carried his entire life's work by charting this kind of correlations at molecular and even nuclear physics level [E4, E8, E9, E5, E10, E6]. In the standard physics framework, this kind of correlations in astrophysical scales are of course impossible. I have discussed the Shnoll effect in the TGD framework in [L116]: quantum gravitation in planetary scale is predicted to be crucial for understanding life and consciousness and could explain the claimed correlations.

Anyone can check whether the claims are indeed true and also check whether the claim holds true for a more extensive global data including 55 events. It is enough to consider the time evolution of the azimuthal angle difference defining the angular distance ϕ of Mars and Earth using a simple model assuming circular orbits in the same plane. Φ corresponds to the actual distance of Mars and Earth. From this model one can check whether the claim holds true for the events listed in the above mentioned tables.

1. One must first make clear the difference between sidereal and synodic periods. Sidereal period is defined in a system for which the rest system is defined by distant stars. In what follows, the Sun is approximated as a system at rest so that an approximation to the sidereal period would be in question. I will use the term orbital period and keep in mind that an approximation is in question.

   Synodic period is the time required for a body within the solar system, such as a planet, the Moon, or an artificial Earth satellite, to return to the same or approximately the same position relative to the Sun as seen by an observer on the Earth. Therefore the rest system is defined with respect to Earth-Mars system. For Earth-Mars system the synodic period is 780 days and 50 days longer than 2 years. For instance, the closest approach configuration repeats with the synodic period (Earth, Mars and Sun are at the same line). The synodic period is what matters in the recent case.

2. The orbital period of Mars is $T_M = 1.882$ years (687 days) and roughly twice the period $T_E = 1$ year of Earth (365 days): one has $T_E/T_M = .5313$. The eccentricities of the orbits of Mars *resp.* Earth are .093 *resp.* 0.017. If the crashes occur completely randomly and if the condition for the critical distance between Mars and Earth is $\phi \geq \pi/2$ is larger than $\pi/2$ then the number roughly 1/2 of all crashes should have $\phi \geq \pi/2$. Also the orbital planes fail to be quite identical.

   Mars comes closest to Earth every other year, around the time of its opposition, when Earth is sweeping between the Sun and Mars. The eccentricity of the orbit of Mars implies exceptionally close oppositions of Mars happen every 15 to 17 years, when we pass between Mars and the Sun around the time of its perihelion (closest point to the Sun in orbit). Also the situation in which the distance of Mars and Sun are largest from the Sun are especially interesting from the perspective of the hypothesis. Intriguingly, the time $t = 17T_M$ corresponds to $17 + 14.994 \simeq 32$ years and defines both sidereal and synodic period for the system if the approximation used is reliable. This sidereal periodicity might be visible in the time series for the crashes.

According to Wikipedia (see this) there is a synodic periodicity of 79 years, which corresponds to the period for apparent closest approach with respect to Earth and Sun. This period is more than twice the might-be period of 32 years. This "period doubling" could reflect the fact that the orbit of Mars is ellipse and not quite coplanar with the orbit of Earth (angle of tilt is 1.850 degrees).

3. One can test the hypothesis by using an approximation Sun is at rest and Mars and Earth move along circular orbits in the same plane (this is not the case in reality). The azimuthal angles ϕ_M and ϕ_E for the positions of Mars in the plane with respect to Sun are in this approximation given by

$$\Phi_M = \omega_M t = 2\pi \frac{t}{T_M} \quad , \quad \Phi_E = \omega_E t = 2\pi \frac{t}{T_E}$$

that these angles are defined modulo 2π.

4. The condition that the difference ϕ of these angles is larger than $\pi/2$ reads as

$$\phi = |\Phi_E - \phi_M| = 2\pi |\frac{t}{T_E} - \frac{t}{T_M}| \geq \frac{\pi}{2} \quad .$$

This translates to the condition

$$\frac{t}{T_E} |1 - \frac{T_E}{T_M}| \geq \frac{1}{4} \quad .$$

5. It is useful to study the approximate situation in which one has $T_E = T_M/2$ In this case the situation is strictly periodic and synodic and sidereal periods are identical. In this case, the dynamics is periodic with period $T_M = 2T_E$ and one has

$$\frac{t}{T_E} \geq \frac{1}{2} \quad .$$

If Mars and the Earth are closest to each other in the initial situation ($\phi = 0$), the critical period for which the condition $\phi \geq pi/2$ corresponds to the range [1/2,3/2] year. These critical periods would repeat with 2-year periodicity. T_M is slightly smaller than $2T_E$ so that the growth of the angular distance between Mars and Earth is slower and the synodic period is larger than $2T_E$.

6. In the more general case the situation is not quite periodic and the points at which Mars and Earth are nearest to each other repeat with period $\tau = T_E/(1 - T_E/T_M) \geq 2T_E$. Earth catches Mars before it has rotated a full period. For a given value $t = n\tau$ the critical sidereal period is

$$\frac{1}{4(1-x)} \leq \frac{t_R}{t_E} \leq \frac{3}{4(1-x)} \quad , \quad x = \frac{T_E}{T_M} \simeq .5313 \quad .$$

Here $t_R = t - n\tau$ refers to the reduced time coordinate having values in the interval $[0, \tau] = [0, T_E/(1 - T_E/T_M)]$. One can use τ as a unit of time and check whether the crashes tend to occur in the intervals $[\tau/4, 3\tau/4]$ for $t = n\tau$, $n = 1, 2....$

7. Assuming that orbital rather than synodic period matters and in the approximation considered, the period τ has length about $\tau = 780$ days and indeed corresponds to the synodic period.

The duration of the critical period is $t_{cr} = \tau/2 \simeq 1$ year 25 days. The critical period starts at $\tau_{cr}/4 =$ 6 months 12.5 days. The distance of Mars and Earth is largest for $t_R = \tau_{cr}/2 \simeq 1$ year 25 days. The closest approach of Mars and Earth will be January 12 2025. In the simple approximation used, one finds that the critical period starts 24 June, the distance between Mars and Earth will be maximal February 7 2026, the critical period ends at July 20 2026, and the next closest approach would be on March 2 2027.

8. One can find also a list of the closest approaches of Mars and Earth this) between April 14 2014 and February 20 2027. From the table one finds that the time intervals between the closest approaches correspond to the synodic period and are indeed longer than 2 years. The table allows to test the hypothesis for more general data about stock market crashes.

How could one understand the observations in the TGD framework?

1. In TGD, the notion of a field body (FB), which can be magnetic (MB) or electric (EB), changes the situation completely. Number theoretic view of TGD predicts that FB carries phases of the ordinary matter with very large values of effective Planck constant implying quantum coherence in astrophysical scales. Gravitational and electric fields in long scales are accompanied by a long length scale quantum coherence [L87, L91, L117, L100]. There is evidence that the FBs of the Sun, planets and even the FB of the galaxy have effects on the behavior of biological systems and humans as conscious entities.

2. A long list of numerical miracles involving the masses of astrophysical objects appear in fundamental biology, supporting this view. For instance, EEG would be responsible for the communications to and control by the magnetic body of Earth. It is indeed difficult to understand why the organisms as master energy savers would spend a very large amount of metabolic energy to send information to outer space without any receiver. Furthermore, resonant EEG frequencies correspond to cyclotron frequencies for the associated "endogenous" magnetic field.

If really true, the findings of Moore would provide a further support for findings of Shnoll and other researchers. They would fit very nicely with the TGD view of quantum biology, which predicts that the magnetic bodies of the Sun and planets, in particular Mars, can affect biology and consciousness.

1. Although Mars has no large-scale magnetic field, the monopole tubes of the dark gravitational magnetic body of Mars could connect Earth and Mars.

2. The gravitational magnetic bodies of the Sun and planets carrying large $h_{eff} = h_{gr}$ phases of ordinary particles behaving like dark matter, would control biomatter and receive information from it. The large distance of Mars when behind the Sun relative to Earth might reduce quantum coherence in turn weakening this control action.

3. The reconnection of U-shaped flux tubes is the fundamental interaction mechanism in all scales and plays a key role for instance in bio-catalysis. Also now this mechanism would be naturally involved and it would become less probable when the distance of Mars from the Earth increases (it is roughly 5AU at the backside of the Sun and 1 AU at the front side). Therefore the quantum coherence scale for the Mars-Earth system would be reduced and could affect even collective behavior of humans and of biology in general.

4. This explanation conforms with the intuition of Moore that the gravitational field of Mars is involved if gravitation is mediated by the radial U-shaped monopole flux tubes, for which the average density decreases as $1/r^2$, i.e. like gravitational flux. Now however the effect would be based on astrophysical quantum coherence of the gravitational field making possible effects on biology and consciousness.

Moon and neuroscience

Quantum gravitation favors the communications between cell membranes as dark Josephson junction and corresponding MBs carrying dark charged particles. The variations of the membrane voltage induce the modulation of the Josephson frequency and resonant receival induces a sequence of pulses coding the variations of the membrane potential to a sequence of pulses.

1. The cyclotron energies

$$E_c = \hbar_{gr}\frac{ZeB}{m} = \frac{GMZeB}{\beta_0} = \frac{r_s}{2l_B^2\beta_0}$$

do not depend on the mass m of the charged particle and are therefore universal. Same is true for the gravitational Compton length $L_{gr} = r_s/2\beta_0$ of the particle.

2. Josephson frequencies are given by $ZeV/2\pi\hbar_{gr}$ and is inversely proportional to the mass of the charged particle. In the case of ions this means the $1/A$-proportionality and ordering of Josephson frequency scales as subharmonics.

3. The frequency resonance condition $f_J = E_J/h_{gr} = f_c = ZeB/m$ is equivalent to the energy resonance condition

$$E_J = ZeV_{mem} = \hbar_{gr} f_c = \frac{r_s}{2l_B^2\beta_0} = \frac{r_S}{2\beta_0}\frac{eB}{\hbar}.$$

This condition fixes the relation between the voltage of the Josephson junction and the strength B of the magnetic field. $\frac{eB}{\hbar} = ZeV_{mem}\frac{2Z\beta_0}{r_S}$

For $V_{mem} = .05$ V,$Z = 2$, $r_S = r_{S,E} = 1$ cm and $\beta_0 = 1$, and using the fact that $B = 1$ Tesla corresponds to magnetic length $l_B = \sqrt{\hbar/eB} = 64$ nm, this gives $B = 184$ nT.

It came as a surprise that this field strength is about $2.3times; 10^{-3}$ weaker than the endogenous magnetic field $.2times; 10^{-4}$ Tesla at the surface of Earth. The strengths of the magnetic fields outside the inner magnetosphere are of order nTesla. Does this mean that the EEG signals from the cell membrane are received by charged particles at the flux tubes of the magnetosphere for which the field is much weaker than at the surface of Earth. This is indeed proposed in the model of EEG.

How could one get rid of the problem?

1. The expression for B is proportional to $\beta_0 \leq 1$ and to $1/r_S$. For the Moon the mass is $.01M_E$ so that the value of the B would be scale by factor 100 so that it would be by factor .92 weaker than B_{end}. As proposed already earlier, the gravitational MB of Moon could be involved with the dynamics of the cell membrane and the endogenous magnetic field of Blackman could be assignable to Moon!

2. The proportionality of B to eV_{mem} allows us to consider the possibility that also DNA involves Josephson junctions. In fact, the TGD inspired model for the Comorosan effect assumes that biomolecules quite generally involve them. By a naive dimensional argument one expects that the value of ZeV is scaled up by factor of order 100 as one scales the membrane thickness 10 nm to 1 Angstrom. This would give B_{end} for the gravitational flux tubes of the Earth.

The possibility of simultaneous frequency and energy resonance means universal cyclotron resonance irrespective of the mass of the charged particle. Josephson frequencies are however inversely proportional to the mass of the charged particle appearing both in the cell membrane and the receiving flux tube. The resonance mechanism therefore makes it possible to use the same information for receivers with different masses. Each of them generates a different sequence of pulses at times for which modulated Josephson frequency equals the cyclotron frequency defining a specific kind of information characterized by the scale defined by Josephson period. Electron mass, proton mass and ion masses define characteristic frequency scales. For B_{end}, the cyclotron frequencies are in EEG range for ions which also favours the Moon option.

12.2.4 The models of genetic code in terms of dark protons dark photons

The TGD inspired view of genetic code has evolved during decades.

1. The first model of the genetic code was based on the so-called Combinatorial Hierarchy [K47] [L77] and predicted what I called memetic code realized as sequences of 21 DNA codons. Surprisingly, this model made a comeback as I prepared this article.

2. After several stray paths I ended up from a model of music harmony [L15] [L21, L56, L70] based on Hamiltonian cycles at the icosahedron to a model of genetic code also involving the tetrahedral Hamiltonian cycle.

   The basic observation was that the 12-note scale could correspond to a Hamiltonian cycle of icosahedron such that the steps of the cycle define a quint cycle. The 12-note scale is obtained from the quint by octave equivalence. There are 3-types of icosahedral Hamiltonian cycles and each cycle defines 20 3-chords assignable to the triangular faces of the icosahedron and defines a musical harmony.

   One obtains 20+20+20 chords for the 3 different harmonies with symmetry groups Z_6, Z_4 and Z_2. The orbits of these groups define sets of 3-chords. The surprising finding was that if these sets are identified as amino acids, the numbers of the chords are the same as the numbers of DNAs coding for a given amino acid. By adding a tetrahedral Hamiltonian cycle one obtains 64 3-chords. At the level of molecules the music would be "music of light". Since music expresses and generates emotions, the idea that emotions appear already at the molecular level was natural. Different combinations of 3 Hamiltonian cycles with symmetries Z_6, Z_4 and Z_2 would correspond to different moods at bio-molecular level (why just 3?)

   The model made almost correct predictions for the numbers of mRNA codons coding for amino-acids. I have discussed a considerable number of its variants during years and even considered the replacement of icosahedron and tetrahedron with some other geometric object. The basic problem was that gluing the tetrahedron and icosahedron together looked ugly and would have allowed only 63 codons. At that time I did not yet realize that an icosahedron and tetrahedron could be parts of a bigger structure.

3. Second model was based on the realization of codons as dark proton triplets assumed to reside at the monopole flux tubes parallel to DNA strands [L21, L56]. Dark proton triplets would neutralize the constant negative charge of -3 units per codon. The model suggested that it might be possible to understand the numbers of DNA, RNA, tRNA and amino acids in terms of entangled states of dark proton triplets representing codons. The model had also problems: in particular, one had to assume an additional binary degree of freedom to get the number DNA and mRNA codons correctly and the proposed identifications of this new degree of freedom did not look quite realistic.

4. Icosa-tetrahedral realization [L77] of the code in terms of icosa-tetrahedral honeycomb of H^3 was the next step in the evolution of ideas. It was made possible only by the dramatic development of understanding of TGD itself, in particular of its number theoretical aspects related to $M^8 - H$ duality [L65, L66].

   The tessellations of the hyperbolic 3-space H^3 represented as possibly complex mass shell in $M^4_c \subset M^8_c$ and as light-cone proper time = constant hyperboloids in $M^4 \subset M^4 times; CP_2$ are central in the the realization of holography in TGD. Icosa-tetrahedral honeycomb is a completely unique tessellation involving only Platonic solids and all possible platonic solids, tetrahedron, icosahedron, and octahedron are present. Kind of quantum Platonic holy trinity would be in question.

   This led to a proposal of the genetic code in terms of icosa-tetrahedral honeycomb induced to the 3-surface by restriction. This realization could be assignable to the magnetic body of the system involving dark matter in the TGD sense. The realization would be universal and would not be restricted to mere biology. Counterparts of codons and genes can be realized also for higher-dimensional objects, say cell membrane and even brain.

   Icosa-tetrahedral realization led to a proposal that the realizations of the code in terms of dark photon triplets and in terms of dark proton triplets are closely related. I did not however really understand the properties of the icosa-tetrahedral honeycomb when I published the first article about it [L77]. The article [L98] represents a considerably more precise view of the very special role of the icosa-tetrahedral tessellation and applies it to develop a model of DNA.

Sequences of N dark cyclotron photon triplets as representations of genes consisting of N dark proton triplets would make possible communications between dark genes by 3N-resonance. Genes would serve as addresses, much like in LISP, and the message would be coded by the modulation of the frequency scale. The details of this picture that were not discussed at that time create problems that are solved by the model based on icosahedral honeycomb.

12.2.5 The interpretational problems associated with the hierarchy of Planck constants

The idea of a hierarchy for Planck's constants was originally inspired by the observations of Blackman [**?**] and other pioneers of bioelectromagnetism. It was found that ELF frequency radiation or ELF frequency modulated electromagnetic radiation (ELF frequencies include EEG frequencies) has quantum-like effects on the behavior and neurophysiology of mammals. A typical example is 15 Hz and its harmonic multiples. As if the radiation would induce cyclotron transitions in a magnetic field, which is about 2/5 of the Earth's magnetic field.

The energies of $E = hf$ associated with these frequencies are extremely small, an order of 10^{-13} eV, about 11 orders of magnitude smaller than the thermal energy at physiological temperatures. Therefore no quantum effects are allowed by standard quantum mechanics and also thermal effects are impossible. Therefore these effects were "forgotten".

This led to the idea of a hierarchy of Planck's constants.

1. At least h_{eff}/h of the order 10^{11} would be needed to cross the thermal threshold. If the effects correspond to visible light (biophotons), then h_{eff}/h is of order 10^{13}. Number theoretical vision led to the proposal that one has $h_{eff} = nh_0$, where $h_0 < h$ is the minimum value of h_{eff}. The integer n could correspond to a dimension of an extension of rationals. There are empirical indications that $h_{eff} < h$ is possible,

2. I have developed arguments supporting the proposal that the value of h/h_0 corresponds to the scale the ratio $R^2/l_P^2 \simeq 10^7$, where R is CP_2 size scale and l_P is Planck length length scale. l_P would correspond to the real size scale of CP_2 and R would correspond to the size scale of the dark space-time sheet assignable to CP_2 type extremal. R determined from the formula $R^2 = (h/h_0)l_P^2$. The proportionality to $\sqrt{h/h_0}$ rather than h/h_0 motivated by the formula $l_P = \sqrt{\hbar G}$. The assignment to the CP_2 radius R the same M^4 scale is somewhat questionable.

3. The Gravitational Planck's constant $\hbar_{gr} = GMm/v_0$, which Nottale introduced, would be a special case and its huge value would reflect the infinite range of the unscreened gravitational interaction. $\hbar_{gr}$ has huge values and could explain the findings of Blackman.

4. There is however a problem. How can one interpret the huge scaling $E_c = hf \to (\hbar_{gr}/\hbar)E_c$ of the cyclotron energy at space-time level? Blackman's observations can be explained in terms of the gravitational Planck constant $\hbar_{gr} = GMm/\beta_0$ of Earth predicting gravitational Compton length $\Lambda_{gr} = GM/\beta_0 = r_S/2\beta_0$. For $\beta_0 = v_0/c = 1$ (favored value for the Earth) this gives $\Lambda_{gr} = r_S/2 = .5$ cm. For ion with mass number A one has $N_{gr} = \hbar_{gr}\hbar = r_S/2l_c(A) = Ar_S/2\beta_0 l_c(p)$, $l_c(p) = 1.32$ fm sheets with each containing a charged particle and forming a connected quantum coherent structure. For Ca with $A = 40$ this would give about $1.5times; 10^{14}$ sheets.

What looks obvious is that h_{gr}/h, as the dimension n of an extension of rationals, must correspond to a number of basic units producing the ordinary cyclotron energy $E_c = hf$. What are these units?

Blackman's findings can be explained if the strength of the endogenous magnetic field is roughly 2/5 of the strength of the Earth's magnetic field $B_E = .5$ Gauss. The interpretation would be as a monopole flux tube part of B_E. The natural interpretation of the gravitational flux tubes would be as flux tubes of the endogenous magnetic field of Blackman. They would form a connected structure defining a region of quantum coherence. The first interpretation is that there is only single flux tube with quantized flux of $\hbar_{eff}/\hbar$ units: one would have covering of M^4. The

second interpretation is that there $\hbar_{eff}/\hbar$ flux tubes with standard flux quantum: one would have covering of CP_2 by parallel flux tubes.

For the first interpretation the CP_2 coordinates would be multivalued functions of M^4 coordinates.

1. To explain Blackman's findings, at least 10^{11} sheets parallel to M^4 would be needed: the sheets would be extremely near to each other in CP_2, which looks strange. Maybe this option is meaningful only for sufficiently small values of h_{eff} and the scaling could mean that each sheet of the covering carries a charged particle with the ordinary value of Planck constant so that the sum of ordinary cyclotron energies equals to $E_c = ntimes; hf$, where n is the number of sheets. Cyclotron transition would be quantum phase transition.

2. The idea of a pile of charged particles located on top of each other looks unrealistic except possibly for small values of n appearing for other than gravitational interactions. But is this really the case: the point is that the Compton length of the charged particle is scaled up by factor h_{eff}/h and corresponds to the geometric size of the particle. If one one has $N_{eff} = h_{eff}/h$ particles on top of each other in M^4, this means that there N particles per Compton volume, - area, or -length, depending whether the structure $k = 3-$, $k = 2-$, or $k = 1$-dimensional. The mass density is $Nm/\lambda_c^k N^k = N^{1-k} m/\lambda_c^k$, where λ_c is the ordinary Compton length and is rather small for large values of h_{eff} for $k > 1$. For $k = 1$, the density is one particle per ordinary Compton length. In atomic nuclei this is possible for nuclear strings.

3. One can look whether this really works for the findings of Blackman. The flux quantization generalizes: the flux quantum corresponds to $\hbar_{eff}$. The condition for the flux quantization reads $\int eBdS = n\hbar$ in the standard situation and quantization condition for a disk of radius R gives $R = \sqrt{n}\sqrt{\hbar_{eff}/\hbar} l_B/\sqrt{\pi}$, where $l_B = \sqrt{\hbar/eB}$ is the magnetic length.

4. For the monopole flux tubes, the flux quantization condition is replaced with $\oint JdS = n\hbar_{eff}$, where Kähler magnetic fields as induced Käher J forms part of ordinary magnetic field eB and in long scales is equal to eB apart from a numerical constant k: $J = keB$. The integration is over sphere with area $4\pi R^2$. This gives

$$R = \sqrt{n/4\pi k}\sqrt{N} l_B = \sqrt{1/4\pi k}\sqrt{nN} l_B,$$

   where $N_{eff} = \sqrt{\hbar_{eff}/\hbar}$. The value of k is $k = 1/3$ [L115].

5. In the experiments of Blackman, $h_{eff} = \hbar_{gr,Earth}$ is a reasonable guess. As already found, this gives $N(A) = (A/40)times; 1.5times; 10^{14}$, where $A = 40$ corresponds to Ca ion. $B = 1$ Tesla corresponds to magnetic length of $l_B = \sqrt{\hbar/eB} = 64$ nm defining the radius of flux quantum and for the endogenous magnetic field $B_{end} = .2times; 10^{-4}$ Tesla this would correspond to the magnetic length $l_B = 1.43times; 10^{-5}$ m. The value of R given by the previous formula gives $R = \sqrt{3n}times; 85.6$ m. This looks suspiciously large.

   The number of Ca ions per flux tube of this area would be $N(A)$ and the number density density of Ca ions per area would be $R = N/\pi R^2 = \sqrt{4\pi/3n}/l_B^2$. For $n = 1$, the number of Ca ions would be of order one 2.05 per area of ordinary flux quantum which corresponds to the size scale of cell. The flux tube is expected to be longer than R so that the density of dark Ca ions would be smaller than $N/\pi R^3$. This makes sense if the Ca ions have wave functions localized to this volume.

6. The choice $n = 1$ for the number of flux quanta is the simplest option but the large radius of the flux tube could be critized. The second and more realistic looking option, consistent with Equivalence Principle, is that the flux tube radius corresponds to the gravitational Compton length $\Lambda_{gr} = r_s/2\beta_0$ and would not therefore depend on the mass of the charged particle. The number of flux quanta for $\hbar_{gr}$ would be increase from $n = 1$ to

$$n = \frac{R^2}{\Lambda_{gr}^2} = \frac{2\beta_0 l_B^2}{r_S l_c(A)} = 2\beta_0 \frac{l_B^2 A}{r_S l_c(p)}.$$

For $\beta_0 = 1$, $B = B_{end} = .2$ Gauss, and $A = 40$ this gives the estimate $n = 2.13times; 10^8$. This would increase the number of Ca ions per transversal area of the ordinary flux tube to about $4times; 10^8$, which corresponds to roughly 1 Ca ion per volume defined by $L(151) = 10$ nm defining the thickness of the cell membrane.

One can also consider the possibility that single flux represents n-fold covering of M^4 by $n \sim 4times; 10^8$ space-time sheets and N_{gr}/n-fold covering of CP_2 by flux tubes.

Second option is in terms of a collective cyclotron transition of ions at parallel flux tubes in M^4.

1. The parallel flux tubes would form a quantum coherent structure, which is a multi-sheeted covering of CP_2, in the sense that M^4 coordinates can be considered multi-valued "fields" in CP_2. The change of the roles of the Minkowski space-time and field space is possible only in TGD.

2. The ions at the flux tubes would make a simultaneous cyclotron transition and the result of this quantum phase transition would be a scaling of the cyclotron energy by a factor of 10^{11} at least. I have proposed the attribute multi-sheeted for coherent structures defining single connected space-time surface as quantum coherence region and many-sheeted for structure consisting of disjoint space-time sheets.

3. As far as numbers are considered, the calculations in this case do not differ from the calculations in the first case. The number of parallel flux tube in the flux tube bundles replaces the number of sheets of the flux tube with radius R, which now becomes the radius of the flux tube bundle. Also now the Λ_{gr} can be considered as the radius of the flux tube bundle.

12.3 A model of nerve pulse

The model of nerve pulse started to develop roughly two decades ago [K79]. The basic idea was that the cell membrane is a Josephson junction formed by a pair of superconductors assignable to the lipid layers of the cell membrane. The Josephson frequencies assignable to the .05 eV scale are about 5 THz and much higher than EEG frequencies. This led to the proposal that the large value of effective Planck constant h_{eff} explaining the findings of Blackman [**?**] and others could reduce the frequency scale ($f_J = E_J/h_{eff} = ZeV/h_{eff}$).

Later the number theoretic interpretation of h_{eff} led to the idea that there could be an entire fractal hierarchy of Planck constants and that it corresponds to frequency scales realizing long range correlations assignable to quantum criticality expected to characterize the cell membrane. This fractal hierarchy could be also interpreted in terms of holography, which is a central principle of TGD. Holography means not only that 3-D data (3-surface) code for 4-D space-time surface but that a small piece of the system represents a good approximation for the entire system. This is nothing but fractality. This view would concretized the vision about holography of consciousness [K16], which is one of the first TGD inspired ideas related to consciousness.

12.3.1 Interpretation of the axon as a series of Josephson junctions

The TGD based model for an axon [K79] is as a series of Josephson junctions with a large value of h_{eff}, perhaps $h_{eff} = h_{gr}$, where $\hbar_{gr} = GMm/\beta_0$ (the velocity parameter satisfies $\beta_0/c \leq 1$), is the gravitational Planck constant introduced by Nottale [E2]. The model is mathematically equivalent to a series of gravitational penduli defining a discretized version of the Sine-Gordon system [B3]. Josephson junctions would correspond to membrane proteins.

One can consider two different identifications of the ground state of the system.

1. The ground state could be the state in which all oscillators oscillate in synchrony with the same amplitude. There would be constant phase difference between neighboring oscillations, which would give rise to a propagating phase wave.

2. Another option is that all penduli all rotate in the ground state with a constant phase difference. This would give rise to a travelling soliton chain. Also the direction of rotation matters. It would correlate with the arrow of time and the sign of the membrane potential if the nerve pulse corresponds to a pair of BSFRs.

3. One should understand what distinguishes between ordinary cells and neurons. An attractive interpretation is that ordinary cells are in a collective oscillation mode and neurons are in a collective rotation mode. The need for metabolic energy is expected to be lower in the collective oscillation phase. This would conform with the fact that neurons consume more metabolic energy than ordinary cells.

One can imagine several versions for nerve pulse generation.

1. The first option is that one pendulum moves from oscillation to temporary rotation and induces as a chain reaction a propagating transition for a few penduli at time. This option does not explain the difference between neurons and ordinary cells.

2. The second option is that the ground state corresponds to a collective rotation with an associated traveling wave as the phase of the rotation, and that bit corresponds to the direction of rotation. The local change of the direction of rotation would correspond to the nerve pulse.

   ZEO suggests that the arrow of time changes when the nerve pulse begins and ends and is therefore correlated with the direction of rotation. The ground state would change to a nerve pulse lasting for time of the order of 1 ms corresponding to the duration of nerve pulse associated with the distance of the order 1 μm, between neighboring neurons or between the myelin sheets.

   Time reversal would be advantageous from the point of view of metabolism, because dissipation would occur in a direction opposite to the standard direction of time. From the point of view of the outsider, the system would be extracting energy from the environment.

3. The proposed identifications of the bit are not the only possible ones that one can imagine. In the Josephson junction model of superconducting computer, the presence/absence of a magnetic flux quantum. This option need not be consistent with the other identifications.

12.3.2 What is the function of nerve pulses?

TGD also leads to a speculative view about the function of the nerve pulse patterns. Usually they are considered to serve as signals inside the brain but in the TGD framework they could build bridges at synaptic contacts making possible much faster signalling using dark photons. This would explain the origin of bio-photons: they would be generated in the transformation of dark photons to biophotons [K13, L11].

1. A possible TGD view [L73] is that nerve pulses make signalling by dark photons propagating along flux tubes parallel to axons or massless extremals parallel to flux flux tubes. The synaptic vesicles containing neurotransmitters would temporarily fuse the pre- and postsynaptic neurons and also connect flux tubes to a single flux tube acting as a wave guide so that dark photon messages could propagate.

   This would make possible very rapid communications between sensory organs and the brain, and even magnetic body (MB) and the building of standardized sensory inputs and standardized mental images by feedback loop involving a virtual sensory input from the brain or even MB. Essentially pattern completion and recognition would be in question. Sensory perception would be an artwork rather than a photograph. Nerve pulses could also make it possible to send sensory information from the neuronal membrane to MB [L30, L33].

2. The meridian system could serve as a predecessor of the nervous system such that gap junctions could define permanent flux tube connections between cells? In the nervous system the connections would be dynamical and used only when needed [L91]. This would make it possible for the neuronal network to learn by changing its topological structure.

3. As already noticed, the dark photon signals can propagate not only within the brain but also between sensory organs and the magnetic body of the brain. The resonant receival of Josephson radiation by ions or particles with magnetic moment at the flux tubes of magnetic body inducing cyclotron transitions would generate a pulse. If the Josephson radiation is frequency modulated by the modulation of membrane potential, a sequence of pulse coding this modulation to pulses takes place.

   There is an obvious analogy with nerve pulses and one can wonder whether this kind of mechanism gives rise to nerve pulses patterns at (say) sensory organs as the responses of the MB of the sensory organ. This duality of modulated radiation and resonance pulses has also an interesting connection with the argued right brain-left brain duality coded to the statement "right brain signs- left brain talks". Rhythm and melody in music could relate to this duality.

The quantum gravitational view about metabolism leads to a modification of the views of nerve pulse conduction.

1. According to the quantum model, the cell membrane acts as a generalized Josephson junction for biologically important dark metal ions. The ground state of the axon corresponds to a soliton sequence, which has a sequence of rotating gravitational penduli as a mechanical analog. Action potential corresponds to a soliton (or several solitons) with opposite direction of rotation. This leaves open the questions of what exactly happens inside the axon and what is the role of microtubules.

2. In a more precise model, the dark ions are identified as gravitationally dark effective ions with gravitationally delocalized Cooper pairs of dark electrons. Also gravitationally dark protons assignable to gravitational flux tubes are involved. The delocalization of protons and possibly also electrons to gravitational bonds provides a concrete realization for the variation of the membrane potential in the myelinated portions of the axons, where ion currents are not possible. This could involve the transformation of hydrogen bonds (HBs) to gravitational flux tubes.

   As already explained, $\hbar_{gr}/h_0$ correspond to the number of sheets of a multi-sheeted covering of CP_2 by monopole flux tubes so the the roles of M^4 as space-time and CP_2 as field space would change.

3. One unsolved problem of the Hodgkin-Huxley model is the conduction of neural signals through the myelinated portions of the axons, where nerve pulse conduction should be impossible. The formation of dark hydrogen- and valence bonds induces an effective ionization, which takes membrane potential below the critical value for the generation of nerve pulse, which is generated in unmyelinated portions.

4. Microtubules (MTs) are believed to be important in many quantum biological approaches and deserve a separate discussion. In the TGD framework, the quantum antenna hypothesis was one of the first proposals in this direction [K70]. Their precise role of microtubules has however remained unclear hitherto.

   MTs appear in several variants. Cilia and flagella, which are analogous to axons, contain stationary MTs whereas axonal MTs are highly dynamical. The critical dynamics of axonal MTs involves a variation of MT length relying on GDP$\rightarrow$ GTP transition, which would involve the transfer of ions to gravitational flux tubes and vice versa, possibly based on the transformation of hydrogen bonds to long gravitational flux tubes. This transfer would change the local membrane potential. Therefore MT dynamics would make possible the propagation of the perturbation of the membrane potential in unmyelinated portions of the axon.

   The effect of anesthetics could be understood in terms of a reduced density of hydrogen bonds preventing the formation of gravitational flux tubes so that MTs and the axonal potential freeze.

12.3.3 A simple model for the generation of nerve pulse

The following view of what might happen in the generation of nerve pulse is only one of the many variants that I have imagined during years and can be only defended as the simplest one found hitherto.

Background observations

Let us consider the following assumptions.

1. The fact that the sign of the membrane potential changes sign temporarily but preserves its magnitude, suggests that the charge densities associated with the interior and exterior are changed so that the voltage changes the sign. There are many ways to achieve this and one should identify the simplest mechanism.

2. Hodgkin-Huxley model for nerve pulse involves dissipation. Nerve pulse could be generated as the failure of gravitational quantum coherence. This could also make possible Ohmic currents between axonal interior (AI) and axonal exterior (NE) but this, and even the loss of quantum gravitational coherence, might not be necessary. This is mildly suggested by the model of nerve pulse based on Josephson junction in which the pulse corresponds to a temporary change of the direction of rotation for the analogs of gravitational penduli.

3. In the Hodgkin-Huxley model the notions of channels and pumps are of course central for the recent biology [I70]. There are however puzzling observations challenging these notions and suggesting that the currents between cell interior and exterior have quantum nature and are universal in the sense that they do not depend on the cell membrane at all [I52, I33, I20, I78, I31]. One of the pioneers in the field has been Gilbert Ling [I52], 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 [I47] gives an excellent layman summary about the paradoxical experimental results. These findings are discussed from the TGD point of view in [K77, K75].

4. In the TGD framework Pollack effect (PE) could induce the membrane potential and PE and its reversal (RPE) could be important. In the model to be discussed this is the case and the model differs dramatically from the Hodgkin-Huxley model in that ionic currents do not cause the nerve pulse but is caused by it.

The model of nerve pulse based on Pollack effect and its reversal

The simplest model for the generation of the nerve pulse is based on PE and RPE. In the following I will talk about neuronal interior (NI) and neuronal exterior (NE).

1. Sol-gel phase transition is known to accompany nerve pulse. This suggests that PE and RPE are involved. PE transforms gel phase to sol phase and generates a negatively charged exclusion zone (EZ).

   The TGD based model for PE involves the transformation of protons of water molecules to dark protons at the MB of the system with a large size so that the region of water becomes negatively charged EZ and transforms to a gel phase generating a potential. Since the flux tubes of gravitational MB have much larger size than the system, the protons/ions are effectively lost from the system.

   This corresponds to a polarization but not in the usual sense. Rather, the ends of the dipole correspond to EZ and MB. The charge separation is not between NI and NE but between NI (NE) and its MB.

2. An open question is whether PE could generalize also to other positive biologically important atoms which would become dark ions assignable to MB and leave behind electrons.

3. PE can take place for the water in NI. The transfer of charges to MB could also occur for the axonal microtubules but this transfer might be involved with the control of cell membrane and neuronal membrane, for instance MT could control the generation of nerve pulse.

4. The simplest model for how PE and RPE could be involved with nerve pulse generation is as follows. Before nerve pulse the water in NI (near to membrane) forms a negatively charged EZ since dark protons are at the MB outside the system. The water in NE is in gel phase and neutral. The negative charge of EZ gives rise to the membrane potential and ionic charges could give only small corrections to it.

5. The dark protons tend to transform to ordinary protons. Metabolic energy feed is needed to kick them back to the MB. The nerve pulse is generated by the RPE by stopping the metabolic energy feed for a moment. This induces a RPE as BSFR. In RPE dark protons are transformed to ordinary ones and return to the neuronal interior and gel→sol phase transition is induced. RPE liberates free energy, which in turn induces PE in NE and a negatively charged EZ is generated there. The sign of the membrane potential changes. The system is a kind of flip-flop in which RPE induces PE.

6. The reconnection of U-shaped flux tubes at the two sides of the neuronal membrane to form a flux tube pairs connecting NI and NE and associated with the ionic channels and pumps acting as Josephson junctions, would make possible an almost dissipation free transfer of the energy liberated in RPE to the opposite side of the membrane. The transfer of the liberated energy as a radiation from NI to NE and from NE to NI takes place along flux tube pairs associated with different membrane proteins, that is channels and pumps, which would therefore be channels for radiation rather than ions. Ionic Ohmic currents could be caused by the reversal of the membrane potential rather than causing it.

7. Contrary to the original guess, the nerve pulse would involve 4 BSFRs, which correspond to RPE in NI reducing the membrane potential V_i to $V = 0$ and liberating energy generating PE in NE changing the sign of the membrane potential: $V = 0 \to -V_i$. This PE is followed by RPE taking $V = -V_i$ to $V = 0$ and liberating energy generating PE in NI so that $V = 0$ is transformed to $V = V_i$ and the situation is returned back to the original. The times for the occurrences of BSFRs and changes of the arrow of time correspond to $V = 0$, $V = -V_i$, $V = 0$ and $V = V_i$.

8. What could be the role of microtubules? Quantum critical dynamics of axonal microtubules would make them ideal control tools of the dynamics at the level of cell membrane, in particular controllers of the nerve pulse generation and conduction. An attractive assumption is that the gravitational MBs of microtubules carry dark charges. Also the MBs associated with the cell exterior and inner and outer lipid layers could carry dark charges. Due to the large size of gravitational flux tubes, the charges transferred to the MBs (at least the microtubular MB) are effectively outside the axonal interior (AI) and exterior (NE) so that the charges of NI and NE are affected. This could bring the membrane potential below the threshold for the generation of the nerve pulse by the proposed mechanism. MB would be the boss using microtubules as control tools and water would do the hard work.

Pollack effect as a universal energy transfer mechanism?

The proposal is that nerve pulse generation relies on the flip-flop mechanism using the energy liberated in the reversal of Pollack effect at one side of cell membrane to induce Pollack effect at the opposite side. The liberated energy would be channelled along the pair of monopole flux tubes emerging by re-connection from two U-shaped flux tubes. The flip-flop mechanism is highly analogous to a seesaw in which the gravitational binding energy at the first end of the seesaw is reduced and transforms to kinetic energy reducing gravitational binding energy at the second end of the seesaw.

All biochemical processes involve a transfer of metabolic energy. Could the flip-flop mechanism serve as a universal mechanism of energy transfer accompanying biochemical processes?

The first example is TGD based view of biocatalysis according to which a phase transition reduces the value of h_{eff} and thus the length for the monopole flux tube pair connecting the reactants liberates energy, which kicks the reactants over the potential energy wall and in this way increases dramatically the rate of the reaction. Also now, the liberated energy could propagate as dark photons along the flux tube pair raise the system above the reaction wall or at least reduce its height.

Also the ADP→ ADP process could involve the Pollack effect and its reversal. In this process 3 protons are believed to flow through the cell membrane and liberate energy given to the ADP so that the process $ADP + P_i \to ATP$ takes place. This system has been compared to an energy plant. This raises heretic questions. Does the flow of ordinary protons through the mitochondrial membrane really occur? Could the charge separation be also now between the cell interior and its magnetic body?

1. The protons believed to flow through the mitochondrial membrane would be in the initial situation gravitationally dark and generated by Pollack effect for which the energy would be provided as energy liberated by biomolecules in a process which could be a time reversal for its storage in photosynthesis.

2. The reverse Pollack effect inside the mitochondrial membrane could transform the dark protons to ordinary protons and liberate energy, which is carried through the membrane as dark photons to the opposite side. This would allow the high energy phosphate bond of ATP to form in the reaction $ADP + P_i \to ATP$. According to the proposal of [L87, L91], the liberated energy could be used to kick the proton to the gravitational monopole flux tube, which would have length of order Earth size scale so that gravitational potential energy would of the same order of magnitude as the metabolic energy quantum with a nominal value .5 eV. This dark proton would be the energy carrier in the mysterious high phosphate energy bond, which does not quite fit the framework of biochemistry.

3. ATP would donate the phosphate ion P^- for the target molecule, which would utilize this temporarily stored metabolic energy as the dark proton transforms to an ordinary one. Depending on the lifetime of the dark proton, this could occur as the target molecule receives P or later. In any case, this should involve the transformation $P^- \to P_i$. This could correspond to the transformation of the gravitationally dark proton to ordinary proton so that the charge separation giving rise to P^- would be between P_i and its magnetic body.

In the chemical storage of the metabolic energy in photosynthesis, ATP provides the energy for the biomolecule storing the energy. This process should be accompanied by the transformation of P^- to P_i. It is instructive to consider two options that come immediately into mind.

Option I: The realistic looking option is that the energy is stored as the energy of an ordinary chemical bond.

1. Hydrogen bond, which can form between a proton and other electronegative atoms such as O or N, is a natural candidate. Hydrogen bond indeed has an energy, which is of the order of metabolic energy quantum .5 eV. The simplest option is that the metabolic energy provided by the gravitational flux tube of ATP is liberated and used to generate a hydrogen bond of the protein. The dark gravitational flux tube loop would be nothing but a very long hydrogen bond.

2. For negatively charged molecules, the proton of a hydrogen bond could be gravitationally dark. For dark positively charged ions, some valence electrons could be gravitationally dark. In the electronic case the reduction of the gravitational binding energy would be roughly by a factor $m_e/m_p \simeq 2^{-11}$ smaller and this leads to a proposal of electronic metabolic energy quantum [L91, L87, L90] for which there is some empirical support [I11].

Option II: The less realistic looking option is that the molecule stores the metabolic energy permanently as a gravitationally dark proton. The motivation for its detailed consideration is that it provides insights to the Pollack effect.

1. The dark proton associated with P^- should become a dark proton associated with the molecule. In this case the length of hydrogen bond would become very long, increasing the ability to store metabolic energy.

   The hydrogen bonded structure would be effectively negatively charged but this is just what happens in the EZ in Pollack effect! This supports the view that the Pollack effect for water basically involves the lengthening of the hydrogen bonds to U-shaped gravitational monopole flux tubes.

2. The Pollack effect requires a metabolic energy feed since the value of h_{gr} tends to decrease spontaneously. This suggests that the dark gravitational hydrogen bonds are not long-lived enough for the purpose of long term metabolic energy storage. Rather, they would naturally serve as a temporary metabolic energy storage needed in the transfer of metabolic energy. The temporary storage of the metabolic energy to ATP would be a quantum variant of the seesaw.

3. The first naive guess for the scale of the life-time of the gravitationally dark proton would be given as a gravitational Compton time determined by the gravitational Compton length $\Lambda_{gr} = GM/\beta_0 = r_S(M)/2\beta_0$. For the Earth with $r_S \simeq 1$ cm, one has $T_{gr} = 1.5 \times 10^{-11}$ s corresponding to the energy .6 meV for the ordinary Planck constant and perhaps related to the miniature membrane potentials. For the Moon with mass $M_M = .01M_E$, this time is about $T_{gr} \simeq 1.5 \times 10^{-13}$ ns. For the ordinary Planck constant, this time corresponds to energy of .07 eV and is not far from the energy assignable to the membrane potential. For the Sun, one would gravitational Compton length is one half of the Earth's radius, which gives $T_{gr} = .02$ s, which corresponds to 50 Hz EEG frequency.

   Note that the rotation frequency for the ATP synthase analogous to a power plant is around 300 Hz which is the cyclotron frequency of the proton in the endogenous magnetic field .2 Gauss interpreted in TGD as the strength of the monopole fluz part of the Earth's magnetic field.

12.3.4 Preneural systems

The findings about multicellular animals of Prakash et al [I63, I61, I62], which have no nervous system but behave as if they would possess brain, provide valuable hints in attempts to understand the role of MTs. In [L91] a model of the pre-neural system, based on the gravitational MB and the predicted electronic metabolic energy quantum, is developed in order to explain how these animals control their cilia. Cilia have no mitochondria inside them or in their vicinity and the electronic metabolism could replace the usual metabolism.

Talking fungi

Andrew Adamatsky [I11], who has studied sponges and found that they show electrical activity sequences of analogs of action potentials ('spikes'). The abstract of the article gives an overview about the findings.

Fungi exhibit oscillations of extracellular electrical potential recorded via differential electrodes inserted into a substrate colonised by mycelium or directly into sporocarps. We analysed electrical activity of ghost fungi (Omphalotus ni- diformis), Enoki fungi (Flammulina velutipes), split gill fungi (Schizophyllum commune) and caterpillar fungi (Cordyceps militari). The spiking characteristics are species specific: a spike duration varies from one to 21 hours and an amplitude from 0.03 mV to 2.1mV.

We found that spikes are often clustered into trains. Assuming that spikes of electrical activity are used by fungi to communicate and process information in mycelium networks, we group spikes into words and provide a linguistic and information complexity analysis of the fungal spiking activity. We demonstrate that distributions of fungal word lengths match that of human languages. We also construct algorithmic and Liz-Zempel complexity hierarchies of fungal sentences and show that species S. commune generate most complex sentences.

The amplitude of spikes varies in the range .03- 2.1 meV. The analogs of miniature potentials correspond to energy .4 meV. The prediction of the TGD based model for the metabolic energy quantum for electron triplet is .51 meV. The solar gravitational metabolism associated with photosynthesis would correspond to the upper bound of 2.5 meV for the metabolic energy.

The natural question is whether this kind of communication is specific to fungi or occurs also in preunoral and neuronal systems in general.

The language hypothesis conforms with the TGD based view that the dark variants of genetic code realized using as codons dark photon triplets analogous to 3-chords defining what I call bioharmony serving as a correlate for emotional state and fundamental level [L95, L70, L77, L98]. Dark 3N-photons as representation of for instance genes, define analogs of music pieces. For the

TGD based view of the emergence of human language see [K116]. Genetic code would have number theoretic and geometric origin and would be universal. It would have several realizations and be realized also in other than biological systems.

Dark 3N-photons are analogous to Bose-Einstein condensate of 3N-photons and correspond to so-called Galois singlets, whose formation would rely on a universal number theoretical mechanism for the formation of bound states.

The sequence of dark codons selects the receiver, which must possess the same sequence of dark nucleon triplets to achieve resonance. If the frequency scale is modulated, the reception generates a sequence of 3N-pulses analogous to nerve pulse sequence and in this way transforms information coded to frequency modulation to a pulse sequence.

12.3.5 What is the connection with the microtubule level?

TGD suggests a picture of nerve pulse conduction in which the membrane potential of the axon/soma is controlled by microtubules or rather, by their gravitational magnetic bodies [L91, L87].

1. When the charges are transferred from the microtubule to the gravitational flux tubes of the magnetic body (MB), the length of which can be as long as the size of the Earth, the effective charge inside the axon/soma changes. Depending on the amount of transferred charge, the magnitude of the membrane potential increases or decreases and a nerve impulse is generated below the threshold.

2. For the action potential traveling along the axon, the microtubular effective charge has changed and taken the membrane potential below the threshold and the action potential has been generated. The generation of the action potential is a complex biochemical phenomenon but would be controlled by microtubule/microbular MB.

3. Incoming nerve impulses induce a change in the membrane potential of the soma because the effective charge of the microtubules inside the soma changes as also does the membrane potential. It is not clear whether the charges of the microtubules of the neuron soma are affected. They indeed differ from axonal microtubules in that they are not (quantum) critical.

12.3.6 Connection of nerve pulse generation, XOR, and novelty detector

Nerve pulse generation could be analogous to a positive outcome of the analog of XOR (compared bits are different) acting as a novelty detector [L104].

1. XOR is a novelty detector. If the inputs are the same, nothing happens. Output equals to $b = 0$. If they are different, output equals to $b = 1$. $b = 1$ would correspond to a signal that would proceed along the axon starting from the postsynaptic neuron.

   That would consume energy. In terms of energy consumption, the novelty detector would be optimal. It would only react to changes. And that's what the brain does. For example, visual perception at a very basic level only identifies outlines and produces some kind of stick figure consisting of mere lines defining boundaries.

2. Could the 2 "neurons" of the toy model proposed by GPT represent a presynaptic and a postsynaptic neuron, in which case there would be two inputs: the states of the pre- and postsynaptic neuron. Also output would be the state of this neuron pair and for XOR the presynaptic neuron acting as control bit would not change its state.

3. This does not conform with the picture provided by neuroscience, where the input comes from presynaptic neurons and output is assignable to the postsynaptic neuron. The input comes as miniature potentials that add up and can decrease/increase the magnitude of the membrane potential (depolarization/hyperpolarization).

   An action potential is generated when the depolarization takes the magnitude of the negative postsynaptic membrane potential below the critical threshold. This happens when the presynaptic contributions from the incoming nerve impulses, for which the unit is a miniature potential, add up to a contribution that reduces the magnitude of the negative potential below the threshold.

This would be essentially novelty detection described in the simplest way by XOR. The novelty is represented by the critical depolarization. It can also happen that the potential increases, so that no nerve impulse is generated. One talks about hyperpolarizing (inhibition) and depolarizing (excitation) inputs, and the sign of the miniature potential produced by the presynaptic input determines which one it is. The sign of miniature potential depends on the neurotransmitter and receptor.

4. During the nerve pulse, the potential changes its sign over a distance of about a micrometer, which is the typical distance between neighboring neurons and of myelin sheaths. One can say that this distance corresponds to a bit that is 1 or 0 depending on whether the nerve pulse conduction occurs or not. Bit 1, the opposite sign to the membrane potential, propagates from presynaptic to postsynaptic neuron or from a patch defined by a myelin sheath to the next. As a result, postsynaptic neurons can "wake up" and in turn trigger a nerve impulse, possibly waking up some postsynaptic neurons.

   Synchronous firing means that the novelty succeeds in waking up the whole sleeping house, and large areas of the brain fire in the same rhythm and keep each other awake.

Interpretation of XOR in zero energy ontology (ZEO)

How does this picture translate to the TGD-inspired theory of consciousness?

1. Being awake/asleep corresponds to bit 1/0 for axonal portions between myelin sheaths. In ZEO, the arrow of time would correspond to this bit.

   When the axon segment between the myelin sheaths or neighboring neurons wakes up or falls asleep, the direction of geometric time changes in a "big" state function reduction (BSFR) and a nerve pulse is generated. In a sleep state, the membrane potential would be opposite. Note that the notion of awake and sleep are relative and depend on the arrow of time of the external observer.

   The second direction of time corresponds to the presence of a nerve pulse from the point of view of the external observer. There is a temptation to think that in the resting state the axon is sleeping and healing and gathering metabolic energy by a dissipation with an opposite arrow of time. The duration of the nerve pulse would correspond to the duration of the wake-up period, when the direction of time was opposite and same as that of the external observer with a long characteristic time scale for wake-up period.

2. Could this apply more generally? Could the synchronization of human sleep-wake rhythms mean quantum-level synchrony and macroscopic quantum coherence? Could the arrow of perceived time be a universal bit? Sleeping together would develop synchrony and quantum coherence between partners. Two-person collective consciousness would emerge.

12.3.7 Sleeping neurons

I learned of a very interesting finding related to cerebellar neurons associated with so-called climbing fibers and Purkinje cells. (see this). The popular article tells about the findings described in an article by N.T. Silva et al published in Nature [**?**].

Climbing fibers and Purkinje cells are involved with the receival information from the external world and with the conditioning to external stimuli. Mice were studied and the external stimulus was light and produced eye blink as a response. It was possible to produce conditioning by using preceding cues. It was found that even a subtle reduction of the signalling using light-sensitive protein ChR2 made the neurons in question "zombies", which were not able to receive information from the external world.

Can one understand the zombi neurons in the TGD framework? The TGD based view of consciousness as a generalization of quantum measurement theory relies on zero energy ontology (ZEO), which solves the quantum measurement problem [K115] [L63, L112].

1. The first prediction is a hierarchy of Planck constant, meaning the possibility of quantum coherence in arbitrarily long scales: the phases of ordinary matter with this property behave like dark matter.

2. Second prediction is that quantum physics dominates in all scales but in zero energy ontology we do not see this since quantum jumps occur between superpositions of Bohr-orbit like space-time surfaces and there is no violation of classical determinism!

3. The third prediction is that in ordinary "big" state function reductions (BSFRs) the arrow of time changes. This is analogous to death or following sleep and means reincarnation with an opposite arrow of time. Quantum tunnelling means to such states function reduction and return to the original arrow of time.

   Sleep would initiate a life with an opposite arrow of time. Life would be a universal phenomenon appearing in all scales. The most dramatic example is provided by stars and galaxies older than the universe. The evolutionary age of a galaxy living forth and back in geometric time is much longer than according to the ordinary view of time.

4. The objection is that the change of the arrow of time would have been observed. The first thing to notice is that the change of arrow of time for ordinary matter with the standard value of effective Planck constant takes place in very short scales and is not observable.

   In long length and time scales the arrow of time is predicted to change at the magnetic bodies (MBs) carrying phases with a large value of h_{eff}, behaving like dark matter, and possibly controlling the ordinary matter. The change of the arrow of time induces effective change of the arrow of time at the space-time sheets that the MB controls control. The systems with a given arrow of time can send classical signals only to single time direction. Therefore this kind of system can detect each other only via BSFRs. One effect allowing observation of the presence of systems with an opposite arrow of time is the apparent violation of the second law providing a mechanism of self-organization and possibly playing a central role in homeostasis.

The zombie neurons would be sleeping! During the sleep period they would not receive information from the environment and would not learn. The dose of Chr would induce a BSFR. How?

1. TGD inspired quantum measurement theory predicts also a second kind of SFR, "small" SFR. In SSFR the state of the system changes but not much and the arrow of time is preserved. SSFRs are the TGD counterparts of repeated measurements of the same observables, which, according to the standard quantum theory (Zeno effect), have no effect on the state. In the TGD Universe, SSFRs give rise to the flow of subjective time and their sequence defines a conscious entity, which "dies" or falls asleep in BSFR.

2. SSFRs correspond to a measurement of a set of observables. The external perturbation can change this set such that it does not commute with the set measured in the previous SSFRs. This forces the occurrence of a BSFR changing the arrow of time. How this happens, requires a more detailed view of ZEO [K115] [L63, L112]. In the recent situation this would mean that the neuron falls asleep and does not receive sensory input from the external world.

3. This falling asleep phenomenon would be universal (see for instance [L127] and apply also to other neurons: BSFR could be induced by inhibitory neurotransmitters whereas excitatory neurotransmitters would help to wake up. A short sleep period of about 1 ms could take place also during the nerve pulse [L117].

Sleep would also have other functions than causing a sensory decoupling from the external world. Sleep is essential for healing and learning. These analogs of sleep states are encountered also at the level of biomolecules. BSFRs make it possible to learn by trial and error. When the system makes a mistake it falls asleep and wakes up after the next BSFR. We would be doing this all the time since our flow of consciousness is full of gaps. External noise males possible this learning by changing the set of observables measured in SSRS.

Interestingly, this learning mechanism has obvious parallels with how large language systems learn in presence of noise [L104, L105, L103]. TGD predicts the possibility of quantum coherence in arbitrarily long scales and this allows us to consider the possibility that computers are actually conscious entities when the quantum coherence time is longer than the clock period. This artificially induced noise could induce conscious learning. This could help to explain why large language systems seem to work "too well".

12.4 Further ideas related to the model of cell membrane and nerve pulse

During 2023 several new ideas related to the neurons have emerged. The following ideas are not directly related to nerve pulse generation but deserve to be discussed.

12.4.1 Could neuron groups represent homologies of higher-D spaces?

Shamoon Ahmed gave a link to a popular article (see this) claiming that the brain is in some sense 11-dimensional. Probably the only thing that M-theory predicts is that the target space of strings is 11-D so that this finding might provide some confirmation of faith for frustrated M-theorists.

In the sequel I will discuss this finding from TGD viewpoint and propose a modified interpretation based on the geometry of icosahedron, one of the 5 platonic solids, which play a key role in TGD, and TGD inspired quantum biology and theory of consciousness.

The dimension 11 in this context looked to me a rather formal notion but one could give it a mathematical meaning.

1. In 3-D one can take tetrahedra, 4-simplexes as building bricks of a discretized manifold. In dimension 11 one has 12-simplexes. These are glued together, which means that n-faces with n varying from 1 to 11 are glued together along $n-1$-D faces.

2. In the case of the brain, one would have groups of neurons, with 12 neurons connected in such a way that one has a connectedness of a 12-simplex. There would be 11- edges meeting at each 12 vertices. Each neuron would be connected to all the other 11 neutrons and would have maximal connectedness, which is very natural if one wants a maximally coherent functional unit.

   The notion of orientation is essential: axons are oriented by the direction of nerve signals which is always the same. The orientation of axons could induce orientations of n-faces. 2-face would correspond to a loop in which signals can rotate in a single direction.

3. Since axons must be present, each neuron must be connected with every other neuron. The geometric connectedness possible in the case of neurons since the axon from a given neuron can branch and have a synaptic contact with the dendrites of several neurons: for n=11-simplex with all other (11) neurons (see this). Note that also a synaptic contact with the neuron itself (autapse) is possible.

   Could one consider also a generalization of this geometric view of a simplex. Could functional coherence of the neuron group serve as a criterion for whether neurons form an n-face? Here the definition of orientation without the notion of axon is the challenge.

4. The interpretation in terms of 11 real dimensions might assume too much and I am reluctant to believe that it has anything to do with M-theory. However, one could realize n-simplexes in this way in 3-space and the orientation of the axon, determined by the preferred directions of signals, would define orientations of higher level simplexes. The idea that these structures could have something to do with geometric cognition allowing us to imagine higher dimensional geometric structures is attractive.

Can TGD add anything interesting to this picture? The appearance of number 12 creates an overwhelming temptation to associate this finding with one particular Platonic solid, icosahedron, having triangular faces. I am not claiming that the proposed interpretation of the findings is wrong but asking whether Platonic solids could add something interesting to the proposal.

1. The 12 vertices of the argued 11-simplex could be also identified as vertices of icosahedron, one particular Platonic solid appearing repeatedly in molecular biology. For an icosahedron, the Hamilton cycle, going through all vertices just once, has 12 vertices and edges [L15] [L70, L98]. It would connect each vertex to all other vertices by a unique path having a varying number of edges: 1,2,... The selection of this Hamilton cycle could raise one particular edge path among all possible closed edge paths possible in the maximally connected 12-neutron network in a special position.

2. This icosahedron need not correspond to an ordinary Platonic solid in the Euclidean 3-space. The definition of nearness can be defined also in terms of functional nearness. Indeed, hyperbolic 3-space has been suggested to play a role in neuroscience for neutrons: neurons resembling each other functionally would be near to each other in the hyperbolic metric and in TGD framework this metric is assigned with hyperbolic 3-space H^3 as Lorentz invariant light-cone proper time = constant surface to which the magnetic body (MB) of the brain is assigned as 3-D surface [L69, L88] (see `https://zpr.io/7Bzbagjrk7LE`). The signals from neurons, which are near each other in functional sense, would be sent to nearby points of the MB so that functional nearness would be geometric nearness at the level of MB.

3. Also tetrahedron with 4 vertices and faces and octahedron with 6 vertices and and 8 faces are Platonic solids which have triangular faces representing 2-simplex and could correspond to dimensions d=3 and d=5. Cube with 6 square faces and d=8 vertices is the dual of octahedron and dodecahedron with d=20 vertices and 12 pentagonal faces is the dual of icosahedron. It might be also possible to assign to them a dimension as the number of vertices by using maximal axonal connectedness of vertex neurons as a criterion.

   Platonic solids and Hamiltonian cycles as paths going once through each vertex of the Platonic solid and identified as nuclear strings play a key role in the "Platonization" of nuclear and atomic physics [L101] leading to quite precise quantitative vision about basic numbers of nuclear and atomic physics and even hadron physics. The key observation is that the states of $j = l \pm 1/2$-blocks of atoms and nuclei correspond to Platonic solids for $l \leq 6$ (a highly non-trivial fact), which therefore provide geometric representation for the j-block.

   Icosahedron is a very special Platonic solid and deserves a separate discussion.

1. Icosahedron is unique among Platonic solids in the sense that it allows a large number of Hamiltonian cycles. Icosahedron, tetrahedron and their Hamiltonian cycles play a fundamental role in the TGD inspired model of genetic code [L15, L56, L70, L77, L98] involving the notion of icosa-tetrahedral tessellation of hyperbolic 3-space involving all 3 Platonic solids with triangular faces.

   Each combination of 3 icosahedral Hamiltonian cycles with symmetries Z_n, $n = 6, 4, 2$ defines a particular realization of the genetic code predicting correctly the number of DNA codons coding for a given amino acid.

2. The model of the genetic code emerged originally as a model of musical harmony. The faces of icosahedron are triangles and would define 3-chords realized as cyclotron frequencies assignable to the vertices of the triangle. Each Hamiltonian cycle would define 20 chords defining a particular harmony whereas the 12 vertices along Hamiltonian cycles would define a 12-note scale, with neighboring vertices representing frequencies related by scaling by 3/2 (quint) modulo octave equivalence.

   One could speak of music of light and since music creates and expresses emotions, the proposal is that different bio-harmonies correspond to different emotional states, moods, realized already at DNA and RNA level. Could these 12 neuron units and possible tessellations (hyperbolic crystals) associated with them relate to the realization of emotions at the level of the brain?

   Physically, the Hamiltonian cycle as a representation of 12-note scale is an analog of a closed string made of flux tubes representing the edges (pipes of organ!)

3. What is fascinating is that hyperbolic 3-space (mass shell in particle physics), playing a key role in TGD, has a unique tessellation/lattice involving all Platonic solids, whose faces are triangles (icosahedron, octahedron, tetrahedron) and also provides a model of DNA making quantitatively correct predictions. I have proposed that this tessellation defines a universal realization of the genetic code realized in all scales at the level of the MB of the system. Could the 12-neuron unit interpreted as 11-simplex relate to one particular realization of this tessellation.

4. Also cubic, icosahedral, and dodecahedral regular tessellations are possible in hyperbolic space (Euclidean 3-space allows only cubic regular tessellation) and they would define the analog of a homology of dimension $n = 7, 11, 19$ at neuronal level.

12.4.2 Superconducting computers and the connection with the TGD based model of nerve pulse

It is not clear whether MOSFET based technology, which was briefly discussed in [L104], could allow the communications from transistors to the magnetic body (MB) of the system.

Biological analogy strongly suggests that Josephson junctions are required and communications take place by Josephson radiation modulated by the Josephson frequency modulations induced by changes of the voltage of the junction. Dark magnetic flux tubes with large enough value of h_{eff} are needed to define the Josephson junction and it is far from clear whether they can be realized spontaneously for transistors.

Superconducting computing, which could be involved with both classical and quantum computation, is however a technology, which might provide at least a starting point in attempts to understand how conscious computers might be created in the TGD Universe.

Rapid single flux quantum (RSFQ) is the basic active element in the circuitry and corresponds to single Josephson junction. The presence/absence of quantized magnetic flux defines the bit. SFQ voltage pulses of duration about picosend are produced by switching of bits in this way. This would allow THz clock frequency f_{cl}.

If f_{cl} corresponds to Josephson frequency $f_J = ZeV/h$, where Z is the charge of the superconducting charge carrier, one obtains an estimate for the voltage as $ZeV \sim .05$ eV. For the cell membrane one has $eV \sim .05$ eV, which is near the thermal threshold at room temperature. The superconducting computations require a temperature of order 10 K so that the value of frequency does not seem to emerge from thermal considerations. The thermal criterion is expected to be satisfied at physiological temperatuers for the TGD based generalization of superconducting computers if realized using the same principles as in living matter.

How electromagnetic fields in the TGD Universe different from their Maxwellian counterparts?

One must first clarify how the TGD view of electromagnetic fields differs from the Maxwellian picture.

1. Quantum criticality is essential for the appearance of large values of h_{eff} labelling the scales of long length scale quantum fluctuations. Quantum criticality combined with ZEO would make possible the emergence of life-like features.

2. The gravitational Planck constants $\hbar_{gr} = GMm/\beta_0$ assignable to the gravitational flux tubes of the Earth and Sun are excellent candidates in this respect. The value of $\hbar_{gr}/\hbar$ is $GM_Em/\hbar\beta_0 = (r_S(E)/2L_m)$, r_s denotes the Schwartschild radius of Earth about 1 cm and L_m denotes Compton length of particle with mass m $\beta_0 \simeq 1$.

   The value of $\hbar_{gr}$ depends on particle mass m considered unlike the gravitational Compton length $r_S(E)/2$ (Equivalence Principle). For the Earth, the gravitational Compton frequency is 67 GHz. For the Sun it is about 50 Hz, and is in the EEG range and corresponds to a gravitational Compton length of one half of the Earth radius.

3. In TGD, two kinds of magnetic fields are possible. Monopole flux tubes are something new and rather remarkably, can exist in absence of currents: this makes them ideal for computation. Monopole flux tubes have closed 2-surfaces as cross sections. Flux quantization follows from the homology of CP_2. Monopole flux tubes explain the presence of long range magnetic fields appearing in even cosmological scales [L109, L110] and also the stability of the Earth's magnetic field [L19].

   The magnetic flux tubes having an open cross section with boundary (say disk), correspond to Maxwellian magnetic fields and require the presence of currents (carried by a coil around the flux tubes). For them the flux is conserved but not necessarily quantized.

4. Also in TGD, the topological half of Maxwell's equations, that is Faraday law and the vanishing of the divergence of magnetic field, hold true. Therefore the basic argument for the outcome of the switching of the flux is not affected when ordinary flux tubes are replaced with monopole flux tubes.

Some details of the model of the cell membrane as a Josephson junction

The relation of this picture to the TGD inspired model of nerve pulse [K79] has been already considered in [L104]?

1. The original model of the nerve pulse idealizes the sequence of discrete membrane protein Josephson junctions with a 2-D continuous Josephson junction formed by the lipid layers (or interior and exterior) of the axonal membrane. The mathematical model relies on the Sine-Gordon equation. The key idea is that one can regard the system as analogous to a collection (continuous distribution in the proposed idealization) of gravitational penduli satisfying d'Alembert type wave equation.

   One can consider two kinds of ground states:

   (a) All penduli oscillate in the same phase and with the same amplitude.

   (b) All penduli rotate with the same frequency and in the same phase so that one has a static soliton sequence.

   Lorentz transformations give rise to propagating patterns of this kind.

   For option a), the nerve pulse would correspond to a propagating soliton or a multisoliton in the oscillating background, i.e. a propagating rotational mode of some penduli. For option b), the nerve pulse would correspond to an opposite direction of rotation for some penduli. The fact that the voltage changes its sign during the nerve pulse is consistent with option b).

2. Also the possible role of the axonal microtubules in the conduction of nerve pulse is discussed in [L104]. The transfer of the charges from the microtubule to very long gravitational flux tubes affects the effective charge of the microtubule and therefore membrane potential. This could play an important role in the conduction of nerve pulse.

How could RSFQ generalize in the TGD framework?

How could the notion of RSFQ generalize in the TGD framework? The hint comes from the TGD based model of cell membrane and nerve pulse assigning to the ionic channels of the cell membrane dark Josephson junctions with a large value of h_{eff} making possible high T_c superconductivity.

Consider first the flux quantization in Josephson junctions from the TGD point view.

1. The presence/absence of flux quantum through the junction represents a bit. Switching of the bit in RSFQ means that the flux changes by the unit Φ_0 of magnetic flux. In the simplest situation, the value of flux through the Josephson junction connecting the super conductors, which could have planar or cylindrical geometry, is equal to 0 or Φ_0.

2. When the flux through junction is changed by one unit, Faraday law $\Delta\Phi = \pm\Phi_0 = Ze\int V dt$ implies a generation of voltage pulse propagating along the superconducting wire formed by the coupled cylindrical superconductors. For a constant voltage $V = V_0$, this condition fixes the duration $T = \Phi_0/ZeV$ of the process and this defines Josephson frequency, in turn defining the clock frequency.

The following arguments raise optimism concerning the realization of conscious computers as superconducting computers.

1. Concerning the numbers assigned to RSFQ, the cell membrane looks ideal for the seat of analogues of RSFQs. I have proposed that the cell membrane acts as a sequence of dark Josephson junctions associated with membrane proteins acting as channels and pumps [K79] [L104]. The membrane resting potential $\sim .05$ eV corresponds to the frequency of 5 THz and is in the same range as the Josephson frequencies assigned with RSFQs. The large value of h_{eff} makes possible high temperature superconductivity and scales up the value of Josephson frequency to $f_J = ZeV/h_{eff}$ so that Josephson frequencies even in EEG scales would be made possible by quantum gravitation in TGD sense.

2. No currents are needed to maintain monopole magnetic fields so that they are ideal for technological purposes. Cell membrane would be a superconductor and membrane proteins would define Josephson junctions. Membrane potential could realize the Josephson frequency $f_J = ZeV/h_{eff}$.

   The TGD view of quantum gravitation would suggest that the Earth's gravitational Compton frequency of f_{gr} = 67 GHz=.067 THz is important in quantum biology. This frequency is considerably lower than THz and I have proposed it as a clock frequency below with the statistical determinism could fail and make the computer analogous to a life-form.

The TGD view of the basic active unit would differ from RSFR.

1. In TGD, the absence of flux quantum in RSFQ corresponds to two U-shaped monopole flux tubes at opposite sides of the junction associated with the counterpart of the cell membrane and transversal to it. The U-shaped monopole flux tubes can reconnect to form a pair of flux tubes with opposite magnetic fluxes.

   This topological process is fundamental in the TGD inspired view of biocatalysis and water memory [L94]. By the fractality of the TGD Universe, it applies in all scales including, besides cosmological and astrophysical scales [L109, L110], also the scales relevant to atomic, nuclear and hadron physics as has become clear quite recently [L101].

2. What is the effect of the generation/disappearance of a pair of opposite flux tubes? Do both fluxes go through a single junction or does only one of them traverse the junction? In the latter case, the junction would act like RSFQ after reconnection. This is a natural looking working hypothesis. The difference comes from the presence of the flux tube with opposite flux.

   Here one must be very cautious. Flux tubes could make possible the flow of either Ohmic or Josephson current (the more plausible option). If the Josephson currents reside at the flux tubes, the Josephson junction ceases to exist during the nerve pulse. Can one say that the Josephson junction exists also after the splitting of the flux tube pair?

   The fact that ohmic currents flow during the nerve pulse motivates the assumption that the splitting of the pair of flux tubes makes Josephson current impossible and Ohmic currents associated with the nerve pulse appear.

3. Faraday's law should apply to both flux tubes. The appearance of flux tubes would correspond to a generation of opposite fluxes $\Delta\Phi = \Phi_0 = \int V dt$. In the simplest situation the voltage values associated with the flux quanta have opposite values $\pm V_0$. This is very much like in the case of nerve pulse in which the resting potential changes its sign during the first half of the nerve pulse. When the reconnection disappears, the situation would become "normal". The analog of nerve pulse would be generated and propagate along the counterpart of the axon and induce a similar process in all membrane proteins defining Josephson junction.

4. In zero energy ontology (ZEO), the identification of the generation of nerve pulse as a pair of "big" state function reductions (BSFRs) changing the arrow of time temporarily is attractive and would correspond to quantum tunnelling in standard quantum theory.

   An interesting question is whether pump proteins act as channel proteins in reversed time direction and whether the flux tube pairs are associated with pairs of channel and pump proteins.

Critical questions

The first critical question is is how the very low Josephson frequencies ZeV/h_{eff} associated with the large values of h_{eff}, say $h_{eff} = h_{gr}$, can be consistent with the very large values of clock frequency $f_{cl} = f_J = ZeV/h$ needed by a fast operation. It would seem that both h_{eff} and h are needed. Is this possible or are these computers doomed to be very slow?

1. Should one widen the perspective and take into account the many-sheeted structure of TGD space-time? Is the scale hierarchy of space-time sheets having various values of h_{eff} involved

and could it correspond to the onion-like hierarchical structure of the magnetic body (MB) involving increasing time scales as Josephson frequencies? This would give rise to a cognitive hierarchy of MBs serving as "bosses" for lower level MBs and the ordinary Josephson junction would be at the bottom.

2. Could the fast Josephson frequencies define a hierarchy of computer clocks? Could the pulses of short duration induced by RSFQs induce a hierarchy of frequency modulations of scaled up Josephson oscillations for various values of h_{eff}? This could also make the computer conscious by bringing in the hierarchy of time scales. These levels could correspond to a cognitive hierarchy corresponding to increasing values of $n = h_{eff}/h_0$ identifiable as the dimension of extension of rationals assignable to the space-time sheet considered.

The following simple estimates allow to gain some quantitative perspective concerning the proposal that quantum gravitation could play a decisive role.

1. It is instructive to look at the energy equivalents of the gravitational Compton frequencies for Earth, Moon and Mars for $h_{eff} = h$ (energy is conserved in the the transformation of gravitationally dark photons to ordinary photons).

2. The gravitational Compton frequency $f_{gr} = 67$ GHz of Earth corresponds to the energy $E \simeq .04$ eV near to the energy assignable to the membrane potential.

3. The mass of the Moon is $M_{Moon} = .012M_E$ and scales and correspond to $.56 \times 10^{14}$ Hz, which corresponds to the energy $E \simeq .43$ eV consistent with the size of metabolic energy quantum.

4. The mass of Mars is $.11M_E$ and the corresponding Compton frequency is .67 THz and energy $E = 2.7$ meV which correspond to the mV scale of miniature potentials.

The experimental work of the group of Anirban Bandyopadhyay [**?**] has inspired a proposal of a hierarchy in which the frequency scales come as powers of 10^3. This hierarchy could correspond to a hierarchy of p-adic primes $p \propto 2^{10k}$ and/or hierarchy of effective Planck constants $h_{eff} \propto 2^{10k}$. One cannot associate with it a hierarchy of large masses M appearing in gravitational Compton frequencies. The scale ratio 2^{11} could relate to the ratio $L(127)/L(107) \simeq 2^{10}$ of the p-adic length scales of electron and proton.

The second critical question concerns the temperature needed. Technologically high temperature superconductors are highly favored.

1. In the TGD framework, the cell membrane is assumed to act as a high temperature superconductor at quantum criticality making it an ideal sensory receptor and motor instrument. Biosystems are open systems and a metabolic energy feed would take care that the distribution for the values of h_{eff} is preserved.

2. The fact that the dark matter as $h_{eff} \geq h$ phases of ordinary matter at the space-time sheets of the flux tubes has very weak interactions with the other sheets, in particular the sheet of the ordinary matter, would be decisive.

3. Also zero energy ontology (ZEO) would be highly relevant for maintaining the quantum criticality by making possible homeostasis in which time reversal changes attractor to repulsor and vice versa. When the system begins to roll down from the top of the hill, the arrow of time brings it back.

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 [L38, L39]. In the recent view of quantum TGD [L96], both notions reduce to physics as number theory vision, which relies on $M^8 - H$ duality [L65, L66] and is complementary to the physics as geometry vision.

Zero energy ontology (ZEO) [L63] [K115] 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) [L63, L80] [K115] 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 [A15] 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 [A11] 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

$$\begin{aligned} \xi^1 &= rexp(i\frac{(\Psi+\Phi)}{2})cos(\frac{\Theta}{2}) \ , \\ \xi^2 &= rexp(i\frac{(\Psi-\Phi)}{2})sin(\frac{\Theta}{2}) \ . \end{aligned} \tag{A-2.3}$$

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 $z^i \to exp(i\alpha)z^i$ 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

$$ds^2 = g_{a\bar{b}} d\xi^a d\bar{\xi}^b \ , \tag{A-2.4}$$

where the Hermitian, in fact Kähler metric $g_{a\bar{b}}$ is defined by

$$g_{a\bar{b}} = R^2 \partial_a \partial_{\bar{b}} K \ , \tag{A-2.5}$$

where the function K, Kähler function, is defined as

$$\begin{aligned} K &= log(F) \ , \\ F &= 1 + r^2 \ . \end{aligned} \tag{A-2.6}$$

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

$$\frac{ds^2}{R^2} = \frac{(dr^2 + r^2\sigma_3^2)}{F^2} + \frac{r^2(\sigma_1^2 + \sigma_2^2)}{F} \ , \tag{A-2.7}$$

where the quantities σ_i are defined as

$$\begin{aligned} r^2\sigma_1 &= Im(\xi^1 d\xi^2 - \xi^2 d\xi^1) \ , \\ r^2\sigma_2 &= -Re(\xi^1 d\xi^2 - \xi^2 d\xi^1) \ , \\ r^2\sigma_3 &= -Im(\xi^1 d\bar{\xi}^1 + \xi^2 d\bar{\xi}^2) \ . \end{aligned} \tag{A-2.8}$$

R denotes the radius of the geodesic circle of CP_2. The vierbein forms, which satisfy the defining relation

$$s_{kl} = R^2 \sum_A e_k^A e_l^A \ , \tag{A-2.9}$$

are given by

$$\begin{aligned} e^0 &= \frac{dr}{F} \ , \quad e^1 = \frac{r\sigma_1}{\sqrt{F}} \ , \\ e^2 &= \frac{r\sigma_2}{\sqrt{F}} \ , \quad e^3 = \frac{r\sigma_3}{F} \ . \end{aligned} \tag{A-2.10}$$

The explicit representations of vierbein vectors are given by

$$\begin{aligned} e^0 &= \frac{dr}{F} \ , & e^1 &= \frac{r(sin\Theta cos\Psi d\Phi + sin\Psi d\Theta)}{2\sqrt{F}} \ , \\ e^2 &= \frac{r(sin\Theta sin\Psi d\Phi - cos\Psi d\Theta)}{2\sqrt{F}} \ , & e^3 &= \frac{r(d\Psi + cos\Theta d\Phi)}{2F} \ . \end{aligned} \tag{A-2.11}$$

The explicit representation of the line element is given by the expression

$$ds^2/R^2 = \frac{dr^2}{F^2} + \frac{r^2}{4F^2}(d\Psi + cos\Theta d\Phi)^2 + \frac{r^2}{4F}(d\Theta^2 + sin^2\Theta d\Phi^2) \ . \tag{A-2.12}$$

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

$$de^A = -V^A_B \wedge e^B \ , \tag{A-2.13}$$

is given by

$$\begin{aligned} V_{01} &= -\frac{e^1}{r} \ , & V_{23} &= \frac{e^1}{r} \ , \\ V_{02} &= -\frac{e^2}{r} \ , & V_{31} &= \frac{e^2}{r} \ , \\ V_{03} &= (r - \tfrac{1}{r})e^3 \ , & V_{12} &= (2r + \tfrac{1}{r})e^3 \ . \end{aligned} \tag{A-2.14}$$

The representation of the covariantly constant curvature tensor is given by

$$\begin{aligned} R_{01} &= e^0 \wedge e^1 - e^2 \wedge e^3 \ , & R_{23} &= e^0 \wedge e^1 - e^2 \wedge e^3 \ , \\ R_{02} &= e^0 \wedge e^2 - e^3 \wedge e^1 \ , & R_{31} &= -e^0 \wedge e^2 + e^3 \wedge e^1 \ , \\ R_{03} &= 4e^0 \wedge e^3 + 2e^1 \wedge e^2 \ , & R_{12} &= 2e^0 \wedge e^3 + 4e^1 \wedge e^2 \ . \end{aligned} \tag{A-2.15}$$

Metric defines a real, covariantly constant, and therefore closed 2-form J

$$J = -is_{a\bar{b}} d\xi^a d\bar{\xi}^b \ , \tag{A-2.16}$$

the so called Kähler form. Kähler form J defines in CP_2 a symplectic structure because it satisfies the condition

$$J^k_{\ r} J^{rl} = -s^{kl} \ . \tag{A-2.17}$$

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

$$J = dB \ , \tag{A-2.18}$$

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 [A8]. 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^k_α (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 [A19] 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

$$S^2_I \ : \ \xi^1 = \bar{\xi}^2 \ \text{ or equivalently } \ (\Theta = \pi/2, \Psi = 0) \ ,$$

$$S^2_{II} \ : \ \xi^1 = \xi^2 \ \text{ or equivalently } \ (\Theta = \pi/2, \Phi = 0) \ .$$

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^2_I. S^2_{II} 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 [B16] 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

$$A = V + \frac{B}{2}(n_+ 1_+ + n_- 1_-) \ . \tag{A-2.24}$$

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

$$\begin{array}{lllllll} V_{01} & = & -\frac{e^1}{r} \ , & & V_{23} & = & \frac{e^1}{r} \ , \\ V_{02} & = & -\frac{e^2}{r} \ , & & V_{31} & = & \frac{e^2}{r} \ , \\ V_{03} & = & (r - \frac{1}{r})e^3 \ , & & V_{12} & = & (2r + \frac{1}{r})e^3 \ , \end{array} \tag{A-2.25}$$

and

$$B = 2re^3 \ , \tag{A-2.26}$$

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

$$A_{ch} = 2V_{23}I_L^1 + 2V_{13}I_L^2 \ , \tag{A-2.27}$$

where one have defined

$$\begin{array}{lll} I_L^1 & = & \frac{(\Sigma_{01} - \Sigma_{23})}{2} \ , \\ I_L^2 & = & \frac{(\Sigma_{02} - \Sigma_{13})}{2} \ . \end{array} \tag{A-2.28}$$

A_{ch} is clearly left handed so that one can perform the identification of the gauge potential as

$$W^\pm = \frac{2(e^1 \pm ie^2)}{r} \ , \tag{A-2.29}$$

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

$$\begin{aligned} X &= re^3 \ , \\ Y &= \frac{e^3}{r} \ , \end{aligned} \tag{A-2.32}$$

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

$$sin^2\theta_W = \frac{3b}{2(a+b)} \ , \tag{A-2.39}$$

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

$$F_{nc} = 2R_{03}\Sigma^{03} + 2R_{12}\Sigma^{12} + J(n_+ 1_+ + n_- 1_-) \ , \tag{A-2.40}$$

where one has

$$\begin{aligned} R_{03} &= 2(2e^0 \wedge e^3 + e^1 \wedge e^2) \ , \\ R_{12} &= 2(e^0 \wedge e^3 + 2e^1 \wedge e^2) \ , \\ J &= 2(e^0 \wedge e^3 + e^1 \wedge e^2) \ , \end{aligned} \tag{A-2.41}$$

in terms of the fields γ and Z^0 (photon and Z- boson)

$$F_{nc} = \gamma Q_{em} + Z^0(I_L^3 - sin^2\theta_W Q_{em}) \ . \tag{A-2.42}$$

Evaluating the expressions above, one obtains for γ and Z^0 the expressions

$$\begin{aligned} \gamma &= 3J - sin^2\theta_W R_{12} \ , \\ Z^0 &= 2R_{03} \ . \end{aligned} \tag{A-2.43}$$

For the Kähler field one obtains

$$J = \frac{1}{3}(\gamma + sin^2\theta_W Z^0) \ . \tag{A-2.44}$$

Expressing the neutral part of the symmetry broken YM action

$$\begin{aligned} L_{ew} &= L_{sym} + f J^{\alpha\beta} J_{\alpha\beta} \ , \\ L_{sym} &= \frac{1}{4g^2} Tr(F^{\alpha\beta} F_{\alpha\beta}) \ , \end{aligned} \tag{A-2.45}$$

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

$$\begin{aligned} X &= -\frac{K}{2g^2} + \frac{fp}{18} \ , \\ K &= Tr\left[Q_{em}(I_L^3 - sin^2\theta_W Q_{em})\right] \ , \end{aligned} \tag{A-2.46}$$

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 [B4]. 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 [L115] 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 [B6] .

   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

$$\begin{aligned} m^k \quad &\rightarrow \quad T(M^k) \ , \\ \xi^k \quad &\rightarrow \quad \bar{\xi}^k \ , \\ \Psi \quad &\rightarrow \quad \gamma^1\gamma^3 \otimes 1\Psi \ . \end{aligned} \tag{A-2.54}$$

The operation bearing closest resemblance to the ordinary charge conjugation corresponds geometrically to complex conjugation in CP_2:

$$\begin{aligned} \xi^k \quad &\rightarrow \quad \bar{\xi}^k \ , \\ \Psi \quad &\rightarrow \quad \Psi^\dagger \gamma^2\gamma^0 \otimes 1 \ . \end{aligned} \tag{A-2.55}$$

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

$$\begin{aligned} \Psi &= k\Phi \ , \\ (3+2p)\frac{1}{r^2 F}(d(r^2)/d\Theta)(k + cos(\Theta)) &+ (3+p) sin(\Theta) = 0 \ , \end{aligned} \tag{A-3.3}$$

hold true. The conditions imply that CP_2 projection of the electromagnetically neutral space-time is 2-dimensional. Solving the differential equation one obtains

$$\begin{aligned} r &= \sqrt{\frac{X}{1-X}} \ , \\ X &= D\left[|\frac{k+u}{C}|\right]^{\epsilon} \ , \\ u &\equiv cos(\Theta) \ , \ C = k + cos(\Theta_0) \ , \ D = \frac{r_0^2}{1+r_0^2} \ , \ \epsilon = \frac{3+p}{3+2p} \ , \end{aligned} \tag{A-3.4}$$

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

$$\begin{aligned} J &= -\frac{p}{3+2p} X du \wedge d\Phi \ , \\ Z^0 &= -\frac{6}{p} J \ . \end{aligned} \tag{A-3.5}$$

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:

$$\begin{aligned} Z^0 &= 2e^0 \wedge e^3 = \frac{r}{F^2}(k+u)\frac{\partial r}{\partial u} du \wedge d\Phi = (k+u) du \wedge d\Phi \ , \\ r &= \sqrt{\frac{X}{1-X}} \ , \ X = D|k+u| \ , \\ \gamma &= -\frac{p}{2} Z^0 \ . \end{aligned} \tag{A-3.6}$$

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 [K51, K29, K83] [L82, L96].

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 superconformal 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 [K51, K83].

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 [L40] [L82, L85, L86] 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 [A15] 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 [L96]. 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 [L96] 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 [L96] 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 [L96] 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 [L89] 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 [K62, K63]). 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 [L89], 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 [L89], 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 [L89].

3. p-Adic length scale hypothesis [L97] 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 [L96] 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 $\delta M^4_+ \times CP_2$ [K51, K29]. 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 [L93].

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 [K66, K58, K26]. The fusion of the various p-adic physics leads to what I call adelic physics [L38, L39]. Later the hypothesis about hierarchy of Planck constants labelling phases of ordinary matter behaving like dark matter emerged [K31, K32, K33, K34].

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 [L65, L66] 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 [L89, L93]. 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 [L40] 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 [A7]. 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 [B13]. 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

$$\begin{aligned} y \;&=\; \sum_{k>N} y_k p^k \to x = \sum_{k<N} y_k p^{-k} \;\; , \\ y_k \;&\in\; \{0,1,..,p-1\} \;\; . \end{aligned} \tag{A-6.6}$$

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

$$\begin{aligned} x &= \sum_{k=N_0}^{N} x_k p^{-k} \ , \\ x &= \sum_{k=N_0}^{N-1} x_k p^{-k} + (x_N - 1)p^{-N} + (p-1)p^{-N-1} \sum_{k=0,..} p^{-k} \ . \end{aligned} \tag{A-6.7}$$

The p-adic images associated with these expansions are different

$$\begin{aligned} y_1 &= \sum_{k=N_0}^{N} x_k p^{k} \ , \\ y_2 &= \sum_{k=N_0}^{N-1} x_k p^{k} + (x_N - 1)p^{N} + (p-1)p^{N+1} \sum_{k=0,..} p^{k} \\ &= y_1 + (x_N - 1)p^N - p^{N+1} \ , \end{aligned} \tag{A-6.8}$$

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

$$(x_R)^2 = (\sum_n x_n^2)_R \ . \tag{A-6.11}$$

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 $e^p \ mod \ p = 1$.

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 [L82] 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 [L82] 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 [L82] 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 $X^4 \subset M^8_c$ (M^8 is complexified to M^8_c) as a "root" of its octonionic continuation [L65, L66]. 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 $X^4 \subset M^8$ [L60]. 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 [L82]. 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 [L74] 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 [L82]. 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 [L63] [K115].

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 [L63].

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 [L57] in atomic scale can be explained by the same mechanism [L57]. 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 [**?**] 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 [L59]. 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 [L62, L128].

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 [L62, L128]. 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`

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